UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 19

PEORIA COUNTY SOILS

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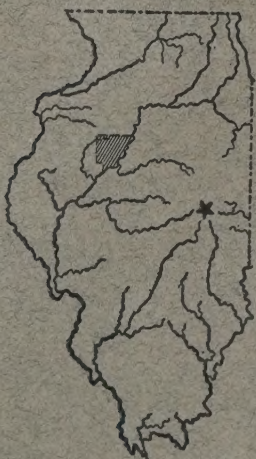

URBANA, ILLINOIS, OCTOBER, 1921

IN RECOGNITION

The Soil Survey of Illinois was organized under the supervision of the late Dr. Cyril G. Hopkins. The work progressed for eighteen years under his guidance and the first eighteen soil reports bear his name as senior author. On October 6, 1919, Dr. Hopkins died in a foreign land in the service of the American Red Cross. It is the purpose to carry on to completion this great work of the Illinois Soil Survey in the spirit, and along the same general plan and lines of procedure, in which it was begun.

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Contents of Soil Report No. 19

PEORIA COUNTY SOILS

than a quarter of Peoria county has been cut up into hills and valleys. This has reduced the value of the land and rendered it unfit for ordinary agriculture, altho much of it is well adapted to pasturing.

A deposit of wind-blown dust, or loess, was made during the Glacial period, to a depth of 5 to 15 feet over the upland. Since this deposit was relatively uniform, it modified the topography but slightly. On the terrace in the northeastern part of the county, the wind has formed sand dunes from the sand deposited by the Illinois river, emphasizing the irregularities that originally existed.

THE GLACIATIONS OF PEORIA COUNTY

Peoria county was first covered by the Illinoisan glacier, which left a deposit of boulder clay, resulting in a partial leveling of the region. After the recession of this glacier, a long period elapsed, during which a soil was formed by the incorporation of organic matter in the glacial material deposited. This soil is known as the Sangamon soil. Then another advance occurred, known as the Iowan glacier, that did not reach Peoria county, but during its melting the region now included in Illinois was probably covered with a deposit of wind-blown dust or loess from 10 to 15 feet thick, burying the Sangamon soil. A new soil, called the Peorian, was formed from the surface of the loess, and after another long period had elapsed, a third ice advance occurred, known as the early Wisconsin glacier. This ice sheet covered the northeastern third of the county, burying the Illinoisan drift and the Sangamon soil still deeper, and covering the Iowan loess and the Peorian soil.

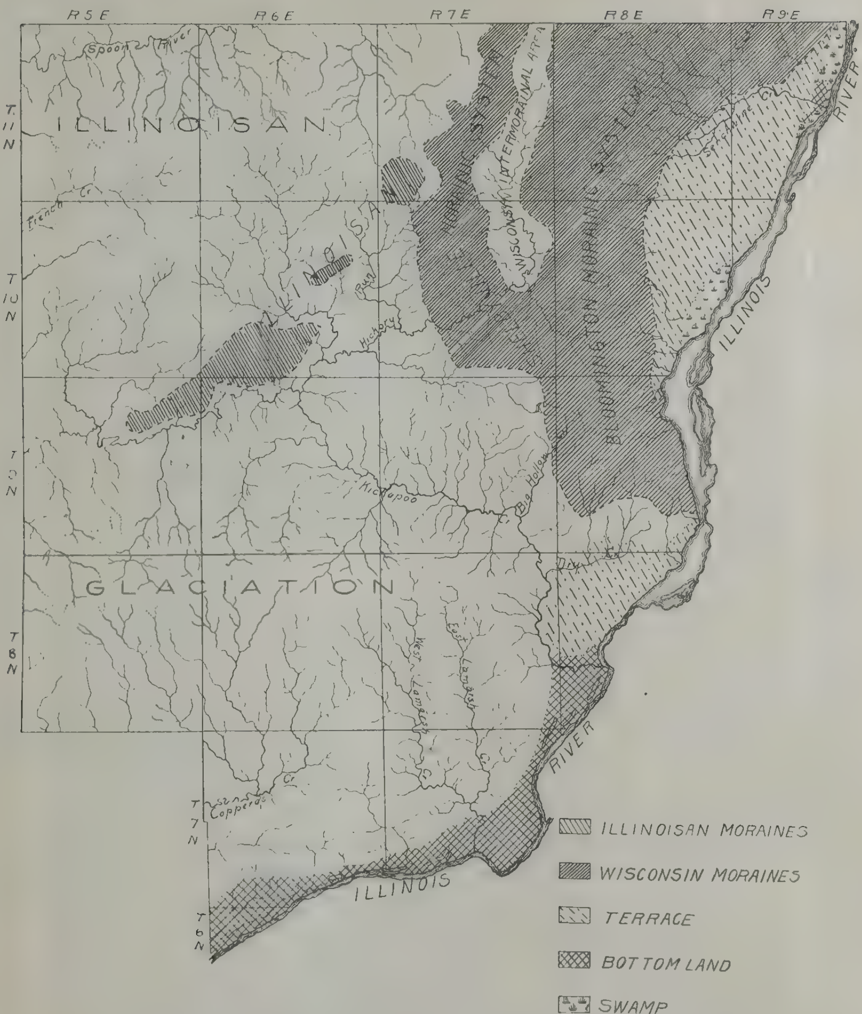
This early Wisconsin glacier built up two extensive moraines, the west one, known as the Shelbyville, and the eastern, the Bloomington. These coalesce in Tazewell county before they cross the Illinois river; then divide south of Dunlap into two distinct ridges, and unite again in the extreme northern part of Peoria county. The deposit of glacial material in the vicinity of these moraines varies from 150 to 200 feet in thickness. In some parts, particularly along the lower Kickapoo creek, this is made up largely of stratified gravel. In places sufficient calcium carbonate has been deposited in this gravel to cement it together, thus producing conglomerate. (See state soil map in Bulletin 193.) A smaller morainal ridge built up by the Illinoisan glacier extends southwest near the center of the western part of the county. The moraines of the early Wisconsin glaciation are about 100 feet higher than the general level of the Illinois glaciation.

The early Wisconsin drift is covered with a deposit of loess from 3 to 6 feet deep, except on the more rolling parts, where it has been largely removed by erosion.

PHYSIOGRAPHY AND DRAINAGE

The altitude of Peoria county varies from 835 feet, the highest point, to below 436 feet, the low-water mark in the Illinois river at Peoria.

The altitudes of some places in the county are as follows: Alta, 751 feet; Brimfield, 729; Chillicothe, 490; Cramer, 765; Dunlap, 724; Edelstein, 781; Eden, 727; Edwards, 519; Elmwood, 626; Glasford, 615; Hanna City, 732; Keller, 801; Kramm, 540; Laura, 732; Mapleton, 467; Maxwell, 594; Monica, 772; Oak Hill, 557; Peoria (low water), 436; Peoria Heights, 768; Pottstown, 486; Princeville, 745; Rome, 485; Trivoli, 748.



MAP SHOWING THE DRAINAGE BASINS OF PEORIA COUNTY WITH MORAINAL, TERRACE, BOTTOM-LAND AND SWAMP AREAS

The entire county lies in the basin of the Illinois river, but the northwest part is drained by Spoon river, while Kickapoo creek drains the larger part of the remainder of the county. The large prairie region lies in the northern and western parts of the county. The northeastern part of the county includes a sand and gravel terrace with irregular areas to the south along the river. The largest of these outside of the Chillicothe area, is at Peoria. The terrace at Peoria occupies at least two distinct levels, the one about a hundred feet above the other. The total prairie area comprizes about 40 percent of the county.

The county contains a large amount of hilly land, totaling about 28 percent of the area. The streams flow in deep valleys that are from 100

to 300 feet below the upland. The principal area of this eroded land is along Kickapoo creek in the central part, while Copperas and Lamarsh creeks with their tributaries are responsible for a large amount of hilly land in the south part. Spoon river has produced an area of several square miles of rough land in the northwest part of the county. Another such area from one to four miles wide has been formed along the Illinois river bluff north of Kickapoo creek.

SOIL MATERIALS AND SOIL TYPES

While the two glaciers which reached Peoria county left extensive deposits of boulder clay or glacial drift, the soils as a rule are not formed from this material. The boulder clay has been covered by a deposit of loess or wind-blown material and this constitutes the soil-forming material. In some of the more rolling areas the loess has been removed and the glacial material is now exposed and constitutes the different soil strata. In some cases, however, sufficient loess still remains to form the surface and subsurface and perhaps part or all of the subsoil.

The soils of the county are divided into the following groups:

(*a*) *Upland Prairie Soils.*—These are rich in organic matter. The partially decayed roots of the wild prairie grasses which once flourished on these areas have been the principal source of the organic matter. The flat prairie land contains the higher amount of this constituent because the grasses and roots grew more luxuriantly there, and the higher moisture content preserved them from complete decay.

(*b*) *Upland Timber Soils.*—These are found in the zones along stream courses, upon which forests have grown for a long period. They contain much less organic matter than the prairie soils, because the large roots of dead trees added but little, and the surface accumulations of leaves, twigs, and fallen trees were burned by forest fires or suffered almost complete decay. The timber lands are divided chiefly into two classes—the undulating and the hilly areas.

(*c*) *Terrace Soils.*—These were formed at the time of the melting of the glacier by deposits of gravel and sand from flooded streams overloaded with sediment. Finer deposits which were later made upon the coarse gravelly material now constitute the soil.

(*d*) *Old Swamp and Bottom Lands.*—These include the flood plains occurring along streams in the older glaciation, the Illinoisan, and some small peaty swamp areas.

(*e*) *Late Swamp and Bottom Lands.*—These include the newer formations occurring along the streams of the early Wisconsin glaciation and along the Illinois river. The sand and gravel terrace was formed during the recession of the Wisconsin glacier, but the only loessial material found there is what has been carried down by streams. This, of course, has been reworked from the ordinary upland loess, and would therefore be classed as an alluvial deposit.

In Table 1 is given the area of each type of soil in Peoria county, and its percentage of the total area. The accompanying map shows the location and boundary of each type of soil, even when the type covers but a few acres.

For explanations concerning the classification of soils and the interpretation of the map and tables the reader is referred to the first part of the Appendix of this report.

TABLE 1.—SOIL TYPES OF PEORIA COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (200, 500, 900, 1100)			
226, 526, 926, 1126	Brown silt loam	208.75	133,600	33.64
520, 1120, 1520	Black clay loam	1.56	998	.25
528, 928	Brown-gray silt loam on tight clay	1.47	941	.24
		211.78	135,539	34.13
	(b) Upland Timber Soils (200, 500, 900, 1100)			
234, 534, 934, 1134	Yellow-gray silt loam	128.13	82,003	20.65
235, 535, 935, 1135	Yellow silt loam	172.59	110,458	27.81
		300.72	192,461	48.46
	(c) Terrace Soils (1500)			
1560	Brown sandy loam	16.66	10,663	2.68
1526	Brown silt loam	6.57	4,205	1.06
1571	Brown fine sandy loam	4.49	2,874	.72
1581	Dune sand	2.81	1,798	.45
1526.4	Brown silt loam on gravel	4.78	3,059	.77
1536	Yellow-gray silt loam over gravel	3.34	2,138	.54
1564	Yellow-gray sandy loam	1.91	1,222	.31
1564.4	Yellow-gray sandy loam on gravel	.16	102	.03
1560.4	Brown sandy loam on gravel	.41	262	.07
1528	Brown-gray silt loam on tight clay	.18	115	.03
		41.31	26,438	6.66
	(d) Old Swamp and Bottom-Land Soils (1300)			
1326	Deep brown silt loam	8.41	5,383	1.35
1354	Mixed loam	38.40	24,576	6.19
1301	Deep peat	.06	38	.01
		46.87	29,997	7.55
	(e) Late Swamp and Bottom-Land Soils (1400)			
1426	Deep brown silt loam	9.55	6,112	1.54
1454	Mixed loam	1.25	800	.20
1415	Drab clay	4.64	2,970	.75
		15.44	9,882	2.49
	(f) Miscellaneous			
	Water	.46	294	.07
	Swamp	3.76	2,407	.60
	Gravel pits	.26	166	.04
		4.48	2,867	.71
	Total area	620.60	397,184	100.00

INVOICE OF PLANT FOOD IN PEORIA COUNTY SOILS

SOIL ANALYSIS

The composition reported for a given soil type is, for the more extensive types, the average of several analyses which, like most things in nature, show more or less variation. For most practical purposes, however, the average composition may be considered sufficient to characterize in a general way the soil type.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed, but it should be understood that the rate of liberation is governed by many factors.

THE SURFACE SOIL

In Table 2 are reported the amounts of organic carbon (the best measure of the organic matter) and the total amounts of the six important elements of plant food—nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium—contained in 2 million pounds of the surface soil of each type in Peoria county. In addition, the table shows the limestone equivalent of the carbonates, in case any are present, or the soil acidity as measured by the amount of limestone required to neutralize it.

The variation among the different types of soil in Peoria county with respect to their content of important plant-food elements is very marked. For example, the deep peat contains, in the plowed soil of an acre, eleven times as much nitrogen as the yellow silt loam, and about four times as much nitrogen but only about one-twentieth as much potassium as the brown silt loam. The total supply of phosphorus in the surface stratum varies from 680 pounds per acre in the dune sand to 2,190 pounds in the deep peat. The magnesium varies from about 4,700 to as much as 30,000 pounds; and the calcium content ranges from less than 6,000 pounds to more than 200,000 pounds per acre. Some types contain an abundance of limestone while others are slightly acid in the surface, more strongly acid in the subsurface, and sometimes devoid of limestone even in the subsoil. Only a very small proportion of the soils of the county contain any limestone in the surface or subsurface to a depth of 20 inches.

Some of the plant-food elements are present in very limited quantities as compared with crop requirements. Some simple computations are of interest in this connection. Take, for example, a four-field crop rotation of wheat, corn, oats, and clover. Assuming yields of 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover, it will be found by easy computation that the most common upland soil of Peoria county, the brown silt loam of the prairie, does not contain more than enough total nitrogen in the plowed soil for the production of such yields for nine rotations (36 years), and the other extensive upland soils in the county are even poorer in this element.

With respect to phosphorus, the condition differs only in degree, this most important upland soil of the county containing no more of that element than would be required for fourteen crop rotations if such yields were secured as are suggested above. On the other hand, the potassium in the surface layer of this common soil type is sufficient for almost 26 centuries if only the grain is sold, or for about 400 years even if the total crops should be removed and nothing returned.

TABLE 2.—PLANT FOOD IN THE SOILS OF PEORIA COUNTY, ILLINOIS: SURFACE SOIL

Average pounds per acre in 2 million pounds of surface soil (about 0-6⅔ inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone equivalent of carbonates present[1]	Soil acidity present[1]
	(a) Upland Prairie Soils (200, 500, 900, 1100)									
−26	Brown silt loam	57,730	4,590	1,080	760	32,870	9,150	10,860		
−20	Black clay loam	75,460	7,190	1,690	1,120	32,530	12,760	20,870		
−28	Brown-gray silt loam on tight clay	43,680	4,000	1,200	720	32,980	7,100	7,820		
	(b) Upland Timber Soils (200, 500, 900; 1100)									
−34	Yellow-gray silt loam	25,310	2,440	900	600	34,320	6,380	12,910		
−35	Yellow silt loam	19,050	1,690	910	330	37,990	9,240	7,850		Sometimes
	(c) Terrace Soils (1500)									
−60	Brown sandy loam	23,910	1,430	770	560	23,850	5,090	5,800		
−26	Brown silt loam	41,220	3,480	1,340	680	41,380	8,920	8,840		
−71	Brown fine sandy loam	34,350	3,260	1,440	670	42,890	14,300	20,410	28,230	
−81	Dune sand	10,220	860	680	260	16,820	5,480	7,560		
−26.4	Brown silt loam on gravel	34,740	2,820	1,040	680	28,240	9,020	9,360		
−36	Yellow-gray silt loam over gravel	24,880	2,920	1,180	560	39,760	4,700	7,300		
−64	Yellow-gray sandy loam	23,100	2,180	1,220	420	32,960	5,360	6,960		
−64.4	Yellow-gray sandy loam on gravel	29,070	2,650	1,070	380	40,130	7,980	8,430		
−60.4	Brown sandy loam on gravel	32,440	2,740	1,080	660	27,140	6,740	7,220		
−28	Brown-gray silt loam on tight clay	43,080	4,020	1,620	720	42,340	9,500	7,240		
	(d) Old Swamp and Bottom-Land Soils (1300)									
−26	Deep brown silt loam	41,920	3,400	1,380	560	34,840	13,980	20,480	24,800	
−54	Mixed loam	27,360	2,360	1,240	480	39,620	16,840	23,700	53,120	
−01	Deep peat[2]	207,920	19,390	2,190	2,900	1,530	6,700	201,810	434,740	
	(e) Late Swamp and Bottom-Land Soils (1400)									
−26	Deep brown silt loam	50,200	4,320	1,570	840	43,990	23,070	31,060	Sometimes	
−54	Mixed loam	43,610	3,750	1,310	710	38,450	30,000	51,750	168,710	
−15	Drab clay	48,340	4,520	1,540	860	44,920	20,640	15,600		

[1]Where neither carbonates nor acidity is reported it is understood that the soil is either neutral or so nearly neutral as to be within the limits of the experimental error of determination.

[2]Amounts reported are for 1 million pounds of deep peat.

TABLE 3.—PLANT FOOD IN THE SOILS OF PEORIA COUNTY, ILLINOIS: SUBSURFACE SOIL

Average pounds per acre in 4 million pounds of subsurface soil (about 6⅔-20 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phos-phorus	Total sulfur	Total potas-sium	Total magne-sium	Total calcium	Limestone equivalent of carbonates present[1]	Soil acidity present[1]
	(a) Upland Prairie Soils (200, 500, 900, 1100)									
−26	Brown silt loam	79,380	6,510	1,790	1,160	66,030	23,170	22,160		
−20	Black clay loam	118,680	9,220	3,020	1,960	65,460	30,040	42,220		
−28	Brown-gray silt loam on tight clay	41,080	4,320	2,000	800	67,360	17,280	14,160		320
	(b) Upland Timber Soils (200, 500, 900, 1100)									
−34	Yellow-gray silt loam	18,210	2,280	1,520	560	71,380	22,980	16,350		Sometimes
−35	Yellow silt loam	16,020	1,870	2,090	420	77,760	30,860	24,590	Sometimes	Sometimes
	(c) Terrace Soils (1500)									
−60	Brown sandy loam	41,760	3,880	1,580	920	49,300	11,880	11,620		
−26	Brown silt loam	56,360	5,240	2,200	1,520	86,600	21,560	18,200		
−71	Brown fine sandy loam	53,080	4,760	2,520	1,300	81,960	35,720	70,660	210,380	
−81	Dune sand	20,240	1,360	1,360	720	35,960	12,240	16,000		
−26.4	Brown silt loam on gravel	63,640	5,760	2,080	1,520	58,360	22,240	18,680		
−36	Yellow-gray silt loam over gravel	19,000	2,560	1,920	520	81,880	12,680	12,600		
−64	Yellow-gray sandy loam	20,240	2,360	2,360	560	72,040	14,880	13,360		
−64.4	Yellow-gray sandy loam on gravel	25,560	3,000	1,620	700	89,600	23,500	15,800		
−60.4	Brown sandy loam on gravel	57,520	4,920	2,000	1,040	56,600	16,400	12,680		
−28	Brown-gray silt loam on tight clay	32,440	3,160	1,840	440	90,400	26,280	14,040		280
	(d) Old Swamp and Bottom-Land Soils (1300)									
−26	Deep brown silt loam	96,240	8,000	3,360	1,160	71,920	31,080	44,320	45,320	
−54	Mixed loam	56,520	4,800	2,520	880	77,360	30,120	42,080	75,680	
−01	Deep peat[2]	552,460	43,420	3,820	7,640	3,920	12,240	342,260	682,760	
	(e) Late Swamp and Bottom-Land Soils (1400)									
−26	Deep brown silt loam	69,780	6,340	2,600	1,400	84,960	46,320	64,220	Sometimes	
−54	Mixed loam	50,500	4,600	2,400	1,040	73,100	69,240	117,920	424,200	
−15	Drab clay	49,000	5,640	2,240	1,040	49,240	42,440	31,400		

[1]Where neither carbonates nor acidity is reported it is understood that the soil is either neutral or so nearly neutral as to be within the limits of the experimental error of determination.

[2]Amounts reported are for 2 million pounds of deep peat.

TABLE 4.—PLANT FOOD IN THE SOILS OF PEORIA COUNTY, ILLINOIS: SUBSOIL

Average pounds per acre in 6 million pounds of subsoil (about 20-40 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone equivalent of carbonates present[1]	Soil acidity present[1]
	(a) Upland Prairie Soils (200, 500, 900, 1100)									
−26	Brown silt loam	38.190	4,250	2,210	1,020	101,580	47,240	34,460		
−20	Black clay loam	49,350	4,110	3,450	1,380	103,860	47,850	52,320		
−28	Brown-gray silt loam on tight clay	30,120	3,720	3,360	540	103,200	46,800	32,220		480
	(b) Upland Timber Soils (200, 500, 900, 1100)									
−34	Yellow-gray silt loam	19,840	2,710	2,940	700	107,540	50,360	28,760	Sometimes	Sometimes
−35	Yellow silt loam	15,340	2,050	3,000	540	113,300	71,560	99,040	Sometimes	Sometimes
	(c) Terrace Soils (1500)									
−60	Brown sandy loam	35,130	3,210	1,920	810	70,860	19,800	15,780		
−26	Brown silt loam	34,500	3,780	3,300	1,140	120,480	44,880	29,340		
−71	Brown fine sandy loam	63,990	4,920	3,660	2,430	113,640	78,420	129,180		
−81	Dune sand	14,160	1,020	1,980	420	51,600	34,740	55,860	432,810	
−26.4	Brown silt loam on gravel	54,780	5,340	3,480	2,040	97,740	42,660	28,320	114,960	
−36	Yellow-gray silt loam over gravel	15,660	2,760	3,720	840	117,600	35,940	21,300		
−64	Yellow-gray sandy loam	20,400	3,000	4,740	300	114,480	36,120	21,180		540
−64.4	Yellow-gray sandy loam on gravel	28,080	3,720	2,700	300	147,180	50,700	20,640		
−60.4	Brown sandy loam on gravel	43,560	3,900	2,460	1,380	84,420	22,980	19,020		
−28	Brown-gray silt loam on tight clay	29,220	3,840	2,880	480	160,800	58,560	22,860		300
	(d) Old Swamp and Bottom-Land Soils (1300)									
−26	Deep brown silt loam	133,140	11,760	5,520	2,040	110,880	54,420	79,620	111,960	
−54	Mixed loam	126,240	9,960	4,620	2,040	113,880	40,140	52,500	38,520	
−01	Deep peat[2]	872,580	51,450	2,850	18,960	4,980	18,450	551,550	1,207,710	
	(e) Late Swamp and Bottom-Land Soils (1400)									
−26	Deep brown silt loam	71,940	6,390	3,330	1,260	115,290	57,570	93,900	Sometimes	
−54	Mixed loam	38,340	3,090	2,700	810	106,440	116,760	210,630	800,820	
−15	Drab clay	47,760	5,040	2,880	960	133,440	60,060	48,660	19,680	

[1]Where neither carbonates nor acidity is reported it is understood that the soil is either neutral or so nearly neutral as to be within the limits of the experimental error of determination.

[2]Amounts reported are for 3 million pounds of deep peat.

These general statements relating to the total quantities of these plant food materials in the plowed soil of the most prevalent type in the county certainly emphasize the fact that the supplies of some of these necessary elements of fertility are extremely limited when measured by the needs of large crop yields for even one or two generations of people.

THE SUBSURFACE AND SUBSOIL

In Tables 3 and 4 are recorded the amounts of plant food in the subsurface and the subsoil of the different types of soil in Peoria county. It should be remembered, however, that these supplies are of little value unless the top soil is kept rich. An important piece of information contained in these tables is that in the common upland soils limestone is seldom found, either in the surface, subsurface, or subsoil. These tables also show great stores of potassium and only limited amounts of phosphorus, in agreement with the data for the surface stratum presented in Table 2.

DESCRIPTION OF INDIVIDUAL SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of Peoria county occupy about 212 square miles, or 34 percent of the entire area of the county. They are black or brown in color owing to their large content of organic matter.

The accumulation of organic matter in the prairie soils is due to the growth of prairie grasses that once covered them. The network of roots formed by these grasses was protected from complete decay by the imperfect aeration resulting from the covering of fine soil material and the moisture it contained. On the native prairies these grasses were usually burned, but the roots accumulated in the soil. From a sample of virgin sod of "blue-stem," one of the most common prairie grasses, it has been determined that an acre of this soil to a depth of seven inches contains as much as 13.5 tons of roots. Many of these roots died each year and by partial decay formed the humus of these dark prairie soils.

Brown Silt Loam (226, 526, 926, 1126)

Brown silt loam is the most extensive as well as the most important type in Peoria county. It covers an area of 208.75 square miles (133,600 acres), or 33.64 percent of the area of the county. This type occupies the undulating to slightly rolling prairie land. It is generally well surface-drained, yet artificial drainage is necessary on some of the flat land or in some of the draws. The morainal areas are sufficiently rolling in some parts to require care in preventing them from washing badly.

Brown silt loam is normally a prairie soil, yet in a few cases forests have recently invaded it. These forests consist quite largely of bur oak, black walnut, elm, and hard maple. A timber soil, so called, of this type is usually spoken of as a black walnut soil and is recognized generally by farmers as being one of the best timber soils because of the fact that it still contains a large amount of organic matter. After the growth of several generations of trees, the organic matter becomes so reduced that the soil is then classed as a true timber type.

The surface soil, 0 to 6⅔ inches, is a brown silt loam, varying on the one hand to black silty clay loam as the type grades into black clay loam, and on the other hand to grayish brown or yellowish brown as it grades into the timber type, yellow-gray silt loam (534 or 934). In physical composition it varies to a slight extent, but it is normally a silt loam containing from 65 to 80 percent of silt, from 10 to 20 percent of sand, and from 7 to 15 percent of clay. The amount of clay increases as the type approaches black clay loam (520 or 1120) and becomes greatest in the level, poorly-drained areas.

The organic-matter content of the surface stratum averages about 4.8 percent, or 48 tons per acre. It varies from 4.2 to 5.5 percent. The amount of organic matter is less in the more rolling areas than in the low and poorly-drained parts, owing to the fact that not only less vegetation grew on the drier, more rolling areas, but also that when incorporated with the soil much of it has been removed by erosion or has undergone more rapid decomposition because of the better aeration and the lower moisture content. As a rule, the early Wisconsin glaciation contains less organic matter than the upper Illinoisan glaciation, the former containing 4.3 percent, while the latter contains an average of 5.2 percent, or about nine tons more per acre.

The natural subsurface varies from 6 to 18 inches in thickness, being thinner on the more rolling areas and decidedly thicker and darker on the more level parts. The top part of the subsurface is a brown silt loam. With depth, this stratum becomes more yellow, gradually passing into the yellow, more clayey subsoil. In physical composition it varies in the same way as the surface soil, but it usually contains a slightly larger amount of clay, especially as it approaches the black clay loam (520 or 1120). Both color and depth vary with topography, the stratum being lighter in color as well as shallower on the more rolling areas and where the type grades into the yellow-gray or the yellow silt loam (534 or 535). The amount of organic matter varies from 2.7 to 4.4 with an average of 3.3 percent, or 66 tons for a stratum 13⅓ inches thick over an acre.

The natural subsoil begins at a depth of 13 to 24 inches and extends to an indefinite depth but is sampled to 40 inches. It varies with topography both in color and in texture and becomes slightly coarser with depth. It consists of a yellow or drabbish mottled yellow clayey silt or silty clay, which is plastic when wet. The texture becomes slightly more silty at a depth of 30 to 36 inches. Where the drainage has been good, the subsoil varies from a bright to a pale yellow color, while with poor drainage it approaches a drab or an olive color with yellow mottlings or a pale yellow color with mottlings of drab.

Each stratum of brown silt loam is pervious, so that drainage takes place with little difficulty.

In the early Wisconsin glaciation, the deposit of loess is so thin in some areas where erosion has taken place, that the boulder clay constitutes part or all of the subsoil. This is not seriously detrimental to the soil, since the glacial drift is not so compact as to constitute a hardpan.

Small grayish patches which have a tight clay subsoil are found in this type. They are really small areas of brown-gray silt loam on tight clay (528) which are too small to be shown on the map. They usually occur where drainage is poor. The soil in these spots is cold, not readily pervious, and needs drainage and the incorporation of organic matter. Limestone is often beneficial. Such spots are commonly spoken of as "buffalo wallows."

Treatment.—While the common brown silt loam is in fair physical condition, yet continuous cropping to corn, or to corn and oats, with the burning of the stalks, is destroying the tilth; the soil is becoming more difficult to work; it runs together more; and aeration, granulation, and absorption of moisture do not take place as readily as formerly. This condition of poor tilth may become serious unless better methods of management are more generally adopted; it is already one of the factors that limits the crop yields. The remedy is to increase the organic-matter content by plowing under farm manure and crop residues, such as corn stalks, straw, and clover.

In all samples collected the laboratory tests indicate a lack of limestone. Field experiments in many instances show a beneficial effect upon crop production from the application of limestone. The analyses show only a moderate quantity of nitrogen in the surface soil. A good system of farming will require that the nitrogen be kept up. In the production of our ordinary field crops this is to be done thru the use of farm manures and the periodic growth of legume crops.

Phosphorus is present in but limited quantity; the permanent maintenance of this kind of soil therefore calls for the liberal application of this element of plant food. Numerous field experiments as well as common farm experience have demonstrated a great financial profit in the application of phosphorus to brown silt loam soil.

The analytical data show an abundant supply of potassium. It is important to note that numerous field experiments have shown no material benefit from the application of potassium in the production of our common field crops on this type of soil.

For an account of field experiments on this type of soil see page 41 of the Supplement.

Black Clay Loam (520, 1120, 1520)

Black clay loam represents the flat, poorly-drained prairie. The upland areas occur in the flat divides and are formed by the accumulation of organic matter and the washing in of fine material from the slightly higher surrounding lands. This type occupies 1.56 square miles (998 acres), or .25 percent of the area of the county. It is so flat that artificial drainage is nearly always necessary.

The surface soil, 0 to 6⅔ inches, is a black, plastic, granular clay loam, varying locally to a black clayey silt loam on the large, flat areas. The organic-matter content varies from 6 to 7 percent, with an average of 6.5 percent, or 65 tons per acre. In physical composition it varies toward the brown silt loam which always surrounds it.

The natural subsurface stratum has a thickness of 10 to 18 inches and varies from a black to a dark brown silty clay loam usually somewhat heavier than the surface soil. The amount of organic matter varies from 4.3 to 5.9 percent, with an average of 5.1 percent, or 102 tons per acre. The subsurface passes into a yellow or a drabbish yellow silty clay. The stratum is quite pervious to water, owing to the jointing, or checking, from shrinkage in times of drouth.

The subsoil to a depth of 40 inches varies from a drab to a yellowish drab or drabbish yellow silty clay. As a rule, the iron is not highly oxidized, because of poor drainage and lack of aeration. The perviousness of the subsoil is about

the same as that of the subsurface, and is due to the same cause. When thrown out on the surface, as in the operation of ditching, it soon breaks into small cubical masses.

Treatment.—Drainage is the first requirement in the management of this type. Altho it usually has but little slope, yet because of its perviousness it is easily tile-drained. Keeping the soil in good physical condition is very essential, and thoro drainage helps to do this to a great extent. With the destruction of the organic matter thru decomposition and the removal of limestone by cropping and leaching, the soil becomes poorer in physical condition, and as a consequence it becomes more difficult to work. Both organic matter and limestone tend to develop granulation. The organic matter should be maintained by turning under manure or such crop residues as corn stalks and straw and by the use of clover and pasture in rotations. Ground limestone should be applied when needed to keep the soil sweet. It should be remembered that the difficulty of working clay soils is in proportion to their deficiency in organic matter.

While black clay loam is one of the best soils in the state, yet the clay and humus which it contains give it the property of shrinkage and expansion to such a degree as to be somewhat objectionable at times, especially during drouth. When the soil is wet, these constituents expand, and when the moisture evaporates or is used by the crops, they shrink. This results in the formation of cracks which are sometimes as much as two or more inches in width at the surface and extend with lessening width to two or three feet in depth. These cracks allow the soil strata to dry out rapidly, and as a result the crop is injured thru lack of moisture. They may do considerable damage by "blocking out" hills of corn and severing the roots. While cracking may not be prevented entirely, good tilth and a soil mulch will do much toward that end. Both for aeration and as a means of producing a mulch for conserving moisture, cultivation is more essential on this type than on the lighter types of soil. It must be remembered, however, that cultivation should be as shallow as possible in order to avoid injuring the roots of the corn.

The results of field experiments on this type of soil are given on page 49 of the Supplement.

Brown-Gray Silt Loam on Tight Clay (528, 928)

Brown-gray silt loam on tight clay occurs in small areas, mostly in Town 11 North, Range 7 East, and occupies 1.47 square miles (941 acres), or .24 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a brown to slightly grayish brown silt loam, and contains 3.8 percent of organic matter, or 38 tons per acre.

The subsurface stratum consists of a brownish gray to a grayish silt loam which passes into tight clay at a depth of 16 to 18 inches. The subsurface contains 1.8 percent of organic matter, or 36 tons per acre in a stratum twice the thickness of the surface.

The subsoil consists of a tight, tough, plastic clay of a brownish yellow to a yellow color.

Treatment.—The type, as a general rule, needs drainage. This condition in the northern part of the county seems to be due to seepage water that is brought to the surface by means of some tight stratum. Practically all this type may

be benefited by the growing of deep-rooting crops and the incorporation of organic matter. As the lower strata of this type are acid, in order to grow clover satisfactorily it is advisable to apply limestone rather liberally, say 4 tons per acre as an initial application and about 1½ tons every four or five years thereafter.

The soil may be greatly improved by turning under crop residues and clover along with about a ton of rock phosphate to the acre, as an initial application and a half ton at intervals of four or five years thereafter.

(b) UPLAND TIMBER SOILS

The upland timber soils occur as irregular zones along streams and on the steeper parts of morainal ridges. They are characterized by a yellow, yellowish gray, or gray color, which is due to the low organic-matter content (organic matter imparting dark colors). The gray is due to the lack of the higher oxids of iron which give the brighter reds and yellows. The deficiency of organic matter has been caused by the long-continued growth of forest trees. After the forest invaded the prairies two effects were produced: first, the shading of the trees prevented the growth of prairie grasses, the roots of which are mainly responsible for the large organic-matter content in prairie soils; second, the trees themselves added very little organic matter to the soil, for the leaves and branches either decayed completely or were burned by forest fires. Furthermore, the organic matter that had been produced by the prairie grasses became gradually dissipated during the occupation of the land by the trees. As a result, the organic-matter content of the upland timber soils has been reduced until in some parts of the state a low condition of apparent equilibrium has been reached. Several generations of trees were necessary to produce the present condition of the soil.

The upland timber soils comprize 300.72 square miles, or 48.46 percent of the entire area of the county.

Yellow-Gray Silt Loam (234, 534, 934, 1134)

Yellow-gray silt loam occurs principally as the outer timber belt along streams. The type covers 128.13 square miles (82,003 acres), or 20.65 percent of the area of the county. In topography it is sufficiently rolling for good surface drainage without much tendency to wash if proper care is taken.

The surface soil, 0 to 6⅔ inches, is a yellow, yellowish gray, or gray to brownish gray silt loam, incoherent and pulverulent but not granular. The more nearly level areas are gray in color, while the more rolling phase of the type has a yellow or a brownish yellow color. After rains this soil usually has a grayish tint. As the type approaches brown silt loam, it becomes decidedly darker. The organic-matter content averages about 2.1 percent, or 21 tons per acre. The variation is from 2 to 2.3 percent, and is chiefly due to differences in topography, being less in the more rolling parts, where some erosion has taken place.

The natural subsurface stratum varies from 8 to 10 inches in thickness. It is usually a gray, grayish yellow, or yellow silt loam, becoming somewhat plastic at depths of 14 to 17 inches. The amount of organic matter is .7 percent. In this type there is almost invariably a decided decrease in the organic-matter content at a depth of about 7 or 8 inches.

The subsoil is a yellow or mottled grayish yellow clayey silt or silty clay, somewhat plastic when wet but friable when only moist. It is pervious to water. The map shows the presence of this type on two glaciations, the early Wisconsin and the upper Illinoisan. The type does not vary much, but on the early Wisconsin glaciation glacial drift is sometimes encountered at a depth of less than 40 inches, while it rarely ever forms the subsoil on the upper Illinoisan. This is due to the fact that the layer of wind-blown loess formed a thicker deposit on the Illinoisan than on the Wisconsin glaciation.

Treatment.—In the management of this yellow-gray silt loam, one of the most essential points is the increasing of the organic-matter content. This is necessary in order to supply nitrogen, to liberate mineral plant food, to give better tilth, to prevent running together, and on some of the more rolling phases, to prevent washing.

Another essential in some localities is that the acidity of the soil be neutralized by the application of ground limestone, so that clover, alfalfa, and other legumes may be grown more successfully. An initial application of 2 to 4 tons per acre is suggested, after which one or two tons per acre every four or five years will be sufficient. Since the soil is poor in phosphorus, this element should be applied. In permanent systems of farming, finely ground natural rock phosphate will usually be found the most economical form in which to supply the phosphorus, altho when prices are favorable steamed bone meal or acid phosphate may well be used temporarily until plenty of decaying organic matter can be provided.

The rotation established on this type should be such that legumes are grown frequently, at least till the organic matter and nitrogen are increased to a considerable extent. A good four-year rotation is corn, oats, clover, and wheat, with a seeding of clover to be plowed under the next spring for corn.

See page 50 of the Supplement for an account of field experiments on this type of soil.

Yellow Silt Loam (235, 535, 935, 1135)

Yellow silt loam covers an area of 172.59 square miles (110,458 acres), or 27.81 percent of the area of the county. It occurs as the hilly and badly eroded land of the inner belt along streams, usually only in narrow irregular strips with arms extending up the small valleys. In topography it is very rolling, and in most places so badly broken that it should not be cultivated because of the danger of injury from washing.

The surface soil, 0 to 6⅔ inches, is a yellow or grayish yellow pulverulent silt loam. It varies greatly in color and texture, owing to recent washing, so that in places the natural yellow subsoil may be exposed. In other places it may be rather brown in color, indicating a good soil. When freshly plowed, the soil appears yellow or brownish yellow, but when it becomes dry after a rain it is of a grayish yellow color. In some places the surface soil is formed from glacial drift, but this is only on very limited areas on the steepest slopes and more commonly on the early Wisconsin deposits than on the Illinoisan. The gravelly character of the early Wisconsin deposit frequently gives small areas of gravelly loam in this type. The organic-matter content varies from 1.2 to 2.5 percent, the average being about 1.5 percent, or 15 tons per acre, the lowest of any type in the county except that of dune sand.

The subsurface varies from a yellow silt loam or a yellow clayey silt loam to a yellow gravelly material. The latter is found more commonly in the early Wisconsin glaciation. The thickness of the natural subsurface stratum varies from 2 to 10 inches. The organic-matter content is .7 percent, or 14 tons per acre in a stratum 13⅓ inches thick.

The subsoil in the Illinoisan glaciation is normally a yellow clayey silt, while in the early Wisconsin it is frequently composed entirely of glacial drift with varying amounts of gravel and sand.

Treatment.—The first and most important point in the management of this type is the prevention of general surface-washing and gullying. If the land is cropped at all a rotation should be practiced that will require cultivated crops as little as possible and allow pasture and meadow most of the time. If tilled, the land should be plowed deeply and contours should be followed as nearly as possible in plowing, planting, and cultivating. Furrows should not be made up and down the slopes. Every means should be employed to maintain and to increase the organic-matter content. This will help to hold the soil and keep it in good physical condition so that it will absorb a large amount of water and thus diminish the run-off.

On very steep land where cultivation is not possible and the timber has been removed, permanent pasture of blue grass and sweet clover should be maintained. This makes an especially good combination, because the sweet clover furnishes nitrogen for the use of the blue grass, and the two together hold the soil so that washing cannot take place.

Additional treatment that is likely to be needed for this yellow silt loam is the use of limestone wherever cropping is practiced. This type is sometimes acid, especially in the surface layer; and the limestone by correcting the acidity of the soil is especially beneficial to the clover grown to increase the supply of nitrogen. Where this type has been long cultivated and thus exposed to surface-washing it is particularly deficient in nitrogen; indeed on such lands the low supply of nitrogen is the factor that first limits the growth of grain crops.

For an account of some experimental tests on this type of soil the reader is referred to page 53 of the Supplement and also to Bulletin 207.

(c) TERRACE SOILS

Terrace soils were formed on terraces or old fills in valleys. The terraces owe their formation generally to the deposition of material from an overloaded and flooded stream during the melting of the glaciers. The material varies from fine to coarse. These valleys were sometimes filled almost to the height of the upland. Later the streams cut down thru these fills and developed new bottom lands, or flood plains, at a lower level, leaving part of the old fill as a terrace. The lowest and most recently formed bottom land is called first bottom. The higher land no longer flooded (or very rarely, at most) is generally designated as second bottom. Finer material later deposited on this sand and gravel of the fill now constitutes the soil. Along some of the streams the fill seems to have been made almost entirely of fine silty material. This is true of the terraces along the Senachwine creek in the northeastern part of the county. The amount of gravel deposited here is very small.

Brown Sandy Loam (1560)

Brown sandy loam covers 16.66 square miles (10,663 acres), or 2.68 percent of the area of the county. The topography is mostly flat, with slight undulations that probably have been produced by the wind. The type occurs principally in the northeastern part of the county in the vicinity of Chillicothe. The city of Peoria is located on another of the largest areas. Smaller areas occur along Kickapoo creek.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam containing about 2 percent of organic matter, or 20 tons per acre.

The subsurface is a brown sandy loam varying in thickness from 6 to 12 inches. The organic-matter content is about 1.7 percent, or 34 tons per acre in a stratum twice the thickness of the plowed soil.

The subsoil is yellow and varies from sand to a silty sand.

Treatment.—As a general rule the drainage of this type is good, but in some cases artificial drainage may be necessary.

In the management of this type it is very necessary that the organic-matter content be increased, since the type is low in this constituent. Crop residues, manure, and legumes should be turned under. The application of limestone will sometimes be necessary in order to obtain good results with clover since all strata lack limestone. The type is low in phosphorus. A ton of rock phosphate applied at first, with about one-half ton every four or five years thereafter, will soon replenish the soil in this essential plant food.

Brown Silt Loam (1526)

Brown silt loam covers an area of 6.57 square miles (4,205 acres), or 1.06 percent of the area of the county. It occupies a lower part of the terrace near the bluff, principally in the northeastern part, and very likely represents an old abandoned river channel which has since been partly filled with fine material washed in by the streams from the upland.

The surface soil, 0 to 6⅔ inches, is a brown to black silt loam containing a variable amount of fine sand which in some cases is present in sufficient quantity to produce a fine sandy loam. The organic-matter content is about 3.6 percent, or 36 tons per acre.

The natural subsurface stratum is a brown silt loam varying from 10 to 16 inches in thickness. The subsurface as sampled contains 2.4 percent of organic matter, or 48 tons in a stratum 13⅓ inches thick.

The subsoil varies from a drab or brownish drab to yellow clayey silt.

Treatment.—All strata are pervious to water, and this provides excellent conditions for underdrainage. It is likely that this type is underlain by sand or gravel, but at such a great depth that it has very little effect on the drainage of the soil. This type is alluvial, and still receives a small amount of deposit on certain parts that adds fertility to it; so the necessity of soil treatment is not so great as if it received no deposit. However, on the parts that do not overflow or receive any deposit from the upland, the maintaining of the organic matter is very important, and the same methods should be used as are recommended for the brown silt loam of the upland already described.

Brown Fine Sandy Loam (1571)

Brown fine sandy loam occurs at the base of the bluff of the Illinois river and is formed by the material washed from the upland. Much of this adjacent upland is of loessial character, containing large amounts of fine sand, and when this is carried down by the small streams, this type is formed. The type covers 4.49 square miles (2,874 acres), or .72 percent of the area of the county. The situation with respect to location and drainage is about the same as that of the brown silt loam (1526).

The surface soil, 0 to 6⅔ inches, is a brown fine sandy loam, the content of sand varying from 50 to 65 percent. The organic-matter content is about 3 percent, or 30 tons per acre. This type varies toward brown silt loam and passes gradually into that type, so that the line between the two is not distinct.

The natural subsurface forms a layer varying from 10 to 14 inches in thickness and is slightly heavier than the surface stratum. In some places the lower depths of the subsurface become quite heavy.

The subsoil varies in color from a yellow to a yellowish drab. It is mostly a silty clay or clayey silt.

Treatment.—All strata are pervious to water, drainage taking place quite readily. The type needs the same treatment as brown silt loam (1526) except that limestone is naturally present here and only sufficient phosphorus need be added to maintain the present supply.

Dune Sand (1581)

The area of dune sand is confined entirely to the terrace in the northeastern part of the county in the vicinity of Chillicothe. When the terrace was formed, the water of the river was much higher than at the present time, and the sand which was carried and deposited by the stream was re-worked by the wind and now constitutes the dunes. This type occupies 2.81 square miles (1,798 acres), or .45 percent of the area of the county. The dunes vary in height from a few feet to as much as 50 feet and are very irregularly distributed. Probably because of the irregularity of the winds, these dunes rarely present what is a normal dune formation; that is, they do not have the usual gradual windward slope and abrupt leeward slope.

The surface soil, 0 to 6⅔ inches, is a loamy sand varying from a yellowish to a brownish color and containing .9 percent of organic matter, or 9 tons per acre. The texture of the sand is quite uniform, being mostly of the medium grade. The dunes have never been timbered.

The subsurface consists of a yellow to slightly brownish yellow sand. It contains about the same percentage of organic matter as the surface stratum, due to the fact that plants growing on this type distribute their roots rather uniformly to a greater depth than they do on other types. The sand is principally of medium grade.

The subsoil is a yellow sand.

Condition.—In this county there would be very little blowing of these sandy areas if they were left in their natural state. In many places the native vegetation has been destroyed by pasturing too closely or by cropping, thus giving the wind an opportunity to do its work. This results in the formation of "blow-outs," which are simply small areas from which the sand is being blown. The action of the wind may result in the ruin of the land if some protection

is not given it. Wind erosion on this soil is worse than water erosion on other soils. Sand possesses very little cohesion, and is therefore readily moved by the wind. When organic matter is added this acts as a feeble cement, which serves to bind the particles together and prevent blowing.

Treatment.—In the management of this type, the principal problems are to prevent blowing and to maintain the supply of nitrogen. Fortunately the best method for preventing blowing will also supply nitrogen. To prevent the movement of sand by the wind it is necessary either to have windbreaks, or to keep the soil covered with vegetation, or to incorporate organic matter. The latter two methods are really the only practical ways of preventing blowing. Every means should be used for increasing the organic matter content and for keeping a cover crop on the soil during the larger part of the year. Small grains are better adapted to accomplish this than corn.

The plants that are best adapted to sand dunes are legumes, which to a very large extent are independent of the nitrogen in the soil. It is interesting to know that a few legumes have adapted themselves to the sand to a remarkable degree. The climbing wild bean is a legume that is growing very abundantly on sand areas. It reseeds itself without any difficulty, and wheat or rye fields are soon covered with a growth of this plant after the crop has been removed. In some cases a ton or more to the acre is produced. It would seem that this plant might well be distributed over all the sand areas, especially those that are likely to blow.

Cowpeas are well adapted to growing on these sand soils. They furnish a large amount of organic matter to hold the sand and also the necessary nitrogen for growing other crops. Where wheat or rye is grown, the drill, with peas, should follow the binder. Normally they will make sufficient growth to add a considerable supply of organic matter and protect the soil during the winter. If the land is reseeded to wheat, the cowpeas may well be allowed to stand and the wheat seeded in them, leaving the vines to protect the sand during the winter. Recent experiments show that two of the best crops for sand are sweet clover and alfalfa.

In the growing of a corn crop on sandy land, the lower blades usually die prematurely. This is commonly spoken of by farmers as "firing" and is attributed to a lack of moisture. While a deficiency of moisture may be responsible to a certain extent, the trouble is more often due to a lack of the element nitrogen. A liberal supply of organic matter, especially that from legumes, will do much to prevent firing.

In the management of a crop on sandy land, cultivation should be practiced no more than is absolutely necessary and should then be as shallow as possible. Sand is naturally well adapted to prevent moisture from evaporating, and there is no necessity for any more cultivation than is really necessary to kill the weeds. Some farmers in Michigan never cultivate their corn crop on sand soil, but instead cut out what few weeds there are with a hoe, and they succeed in raising larger crops than where cultivation is practiced.

Foresting is a practical way of conserving these sand soils. The black locust (a leguminous tree) seems to do exceptionally well on sand. One difficulty with this tree, however, is that it is damaged by borers; but if it is used to start a growth and hold the sand, other trees may then be grown

and the result will be that the sand will be held permanently. After the blowing of sand is once stopped, very careful treatment is required to prevent a recurrence of the trouble. Pasturing should be done very carefully, so that the grass will not be entirely destroyed.

With respect to the acidity, analysis shows limestone to be lacking in the surface and subsurface. For satisfactory results, therefore, an application of 2 to 4 tons per acre of limestone is recommended, and the supply should be maintained by subsequent applications every four or five years.

As the nitrogen content is exceedingly low, successful crop production rests upon the building up of the supply of this element, and this is to be accomplished thru the growing of legumes, as recommended above.

The phosphorus content of sand soils is not high, there being only 680 pounds of this element per acre in the plowed soil, but it exists to a considerable extent in other constituents than sand grains. The United States Bureau of Soils separated two types of sandy soil—glacial sand and sandy loam—into coarse, medium, and fine particles, analyzed each grade for phosphorus, and found that as an average of the two soils the fine portion was eighteen times as rich in the element phosphorus as the coarse. Under successful cropping, such a limited amount of phosphorus would, however, sooner or later, become exhausted, altho field experiments on sandy soil might not indicate a need of this element at first.

The total supply of potassium is large, but as to its availability for growing crops field experiments on sandy soil have shown some discrepancies in results, owing probably to a variation in the condition in which the potassium exists. Definite recommendations, therefore, regarding the application of potassium to this type of soil must await the collection of more reliable information. (On swamp sands and sandy loams long exposed to leaching, potassium is often the first limiting element, especially where a fair supply of humus exists, as in the so-called "black sand.")

For an account of field experiments on dune sand see page 55 of the Supplement.

Brown Silt Loam on Gravel (1526.4)

Brown silt loam on gravel occupies 4.78 square miles (3,059 acres), or .77 percent of the area of the county. It occurs in the northeast part of the county immediately around Chillicothe. It varies in topography from flat to rolling.

The surface soil, 0 to 6⅔ inches, is a brown to yellowish brown silt loam, containing more or less sand. Small areas occur that are sufficiently sandy to be classed as sandy loam, but these are not large enough to be shown on the map. Occasionally gravel and even stones are found in the surface soil. On some of the steepest slopes the gravel is exposed, giving a silty gravelly loam. The organic-matter content is 3 percent, or 30 tons per acre.

The natural subsurface soil varies in thickness, depending upon the depth to gravel, which varies from 16 to 24 inches, with an average depth of about 20 to 22 inches.

The subsoil consists mostly of gravel mixed with small stones which vary to 2 inches in diameter.

Treatment.—The proximity of gravel to the surface renders the soil a somewhat inferior one, because of the effect during drouth. Alfalfa does well

on the type and because of its deep-rooting characteristic is much to be preferred to corn. The same precautions must be taken in maintaining the organic-matter content as are necessary for the upland brown silt loam, and if this constituent is kept supplied to the soil, the injurious effect of drouth will not be so great. An application of 2 tons of ground limestone should be made to enable legumes to be grown more successfully. Applications of rock phosphate are recommended in view of the fact that the soil is not high in phosphorus content.

Yellow-Gray Silt Loam Over Gravel (1536)

Yellow-gray silt loam over gravel occurs almost entirely along the smaller streams of the county, and represents old fills or terraces of fine material. The type occupies 3.34 square miles (2,138 acres), or .54 percent of the area of the county. These terraces lie from 25 to 75 feet or more above the stream, and are usually undulating in topography.

The surface soil, 0 to 6⅔ inches, consists of a yellow to yellowish gray silt loam, and contains 2.1 percent of organic matter, or 21 tons per acre.

The subsurface is a yellow silt loam, becoming slightly heavier with depth. It contains .8 percent of organic matter.

The subsoil differs but little from the subsurface in either color or texture.

Treatment.—The type requires the same treatment as the upland yellow-gray silt loam (534).

Yellow-Gray Sandy Loam (1564)

Yellow-gray sandy loam occurs along the Illinois river in the southern part of the county. It occupies 1.91 square miles (1,222 acres), or .31 percent of the total area of the county.

The surface soil, 0 to 6⅔ inches, is a yellow to brownish yellow sandy loam containing 2 percent of organic matter, or 20 tons per acre. Its sand content is not large enough to make it very light.

The subsurface consists of a yellow sandy loam, which becomes lighter with depth.

The subsoil is irregular in texture, in some places consisting of sand and in others of sandy silt.

Treatment.—The treatment should be the same as for the upland yellow-gray silt loam (534).

Yellow-Gray Sandy Loam on Gravel (1564.4)

Only a few small areas of yellow-gray sandy loam on gravel occur in the county, all of them together covering only 102 acres.

The surface varies considerably in texture, sometimes merging into a silt loam. It also varies in color and organic-matter content. It contains about 2.9 percent of organic matter, or 29 tons per acre.

The subsurface is a yellow or brownish yellow sandy loam, with 1.4 percent of organic matter.

The subsoil is a yellow to grayish yellow sandy silt to slightly silty sand, passing into gravel at depths varying from 20 to 30 inches.

Treatment.—The type requires the same treatment as the yellow-gray silt loam of the upland (534).

Brown Sandy Loam on Gravel (1560.4)

Brown sandy loam on gravel covers .41 square miles (262 acres) and occurs on the terrace in the northeast part of the county.

The surface soil, 0 to 6⅔ inches, contains 2.8 percent of organic matter and consists of a brown sandy loam containing more or less gravel.

The subsurface contains 2.5 percent of organic matter and differs but little from the surface soil either in texture or in color.

The subsoil is composed almost entirely of gravel, which begins at depths varying from 16 to 24 inches.

Treatment.—This type requires that the organic-matter content be maintained. Rock phosphate should be applied at the rate of ½ to ¾ ton per acre every four or five years.

Brown-Gray Silt Loam on Tight Clay (1528)

Brown-gray silt loam on tight clay occurs in small areas on the terrace in the northeast part of the county. It covers only .18 square miles, or 115 acres.

The surface soil, 0 to 6⅔ inches, is brown to grayish in color, containing small spots much lighter in color than the average. It contains 3.7 precent of organic matter, or 37 tons per acre.

The natural subsurface, which varies from 6 to 10 inches in thickness, is a grayish silt loam, very friable and rather impervious. It contains 1.4 percent of organic matter. This is immediately underlain by a tight clay of a brownish yellow color, which is very impervious to water, thus interfering seriously with drainage. This tight stratum is from 10 to 16 inches thick. A more open stratum is found beneath.

Treatment.—The type needs drainage first, then heavy applications of limestone, and deep-rooting crops to open up the subsoil.

(d) OLD SWAMP AND BOTTOM-LAND SOILS

Deep Brown Silt Loam (1326)

Deep brown silt loam occurs in the western and northern parts of the county along the small streams, and covers an area of 8.41 square miles (5,383 acres), or 1.35 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a brown silt loam varying toward sandy loam. It contains 3.6 percent of organic matter.

The subsurface is a brown silt loam, and in the sample collected contained slightly more organic matter than was found in the surface stratum.

The subsoil, 20 to 40 inches, is a brown silt loam containing the same percentage of organic matter as the surface. This peculiarity in the organic-matter content has been produced by the burying of considerable quantities of organic matter in the deposition of sediment during overflow. The sediment also carries some organic matter.

Treatment.—Because of the occasional deposition of new material, little need be done beyond good cultivation, in keeping up the productiveness of this soil.

Mixed Loam (1354)

Mixed loam occurs along the streams in the southern part of the county in the Illinoisan glaciation. It covers an area of 38.40 square miles (24,576 acres), or 6.19 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, varies so much that it is impossible to separate it into distinct types. In some places there are small areas of sand, in others sandy loam, in others silt loam, and during flood times the areas may be changed entirely, so that it is impracticable to map separate types. The analysis gave 2.4 percent as the organic-matter content.

The subsurface varies with the surface and contains about the same amount of organic matter.

The subsoil varies even to a greater extent than the other strata. The sample which was taken contained more organic matter than either the surface or the subsurface. This can be accounted for in the same way as in the preceding type.

Treatment.—No special soil treatment is recommended.

Deep Peat (1301)

The total area of this type in the county is only 38 acres.

The surface soil contains 36 percent of organic matter, or 180 tons per acre for 1,000,000 pounds of plowed soil. *The subsurface* is very similar to the surface, but contains 48 percent of organic matter. *The subsoil* contains 50 percent of organic matter.

(e) LATE SWAMP AND BOTTOM-LAND SOILS

Deep Brown Silt Loam (1426)

Deep brown silt loam covers 9.55 square miles (6,112 acres), or 1.54 percent of the area of the county. It occurs almost entirely along the Illinois river and represents the later deposit.

The surface soil contains about 4.3 percent of organic matter, or 43 tons per acre and is of a dark brown to black color. In texture it varies, becoming almost heavy enough for clay loam in some small areas. This type is seldom very sandy, as it is usually formed in back water and away from the main currents of the river.

The subsurface soil is lighter in color than the surface, containing only 3 percent of organic matter.

The subsoil varies from drab to drabbish yellow, and contains 2 percent of organic matter.

Treatment.—Good cultivation to keep down the weeds is about all that can be done for this type where it is subject to occasional overflow. In case it is leveed, means ought to be taken to maintain the fertility.

Mixed Loam (1454)

Mixed loam occurs as bottom land along the smaller streams and where these streams carry material on to the terrace or larger bottom lands. The soils are so mixed that it would be practically impossible to separate them into different types.

The surface soil contains approximately 3.8 percent of organic matter, or 38 tons per acre, and varies from a sand to a clay loam.

The subsurface soil contains about 2.2 percent of organic matter.

The subsoil is of a yellowish or drabbish color and contains about 1.1 percent of organic matter.

Drab Clay (1415)

In the southern part of the county the bottom land contains several areas of drab clay. The total area amounts to 4.64 square miles (2,970 acres), or .75 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a granular, plastic clay of a dark drab to almost black color. It contains 4.2 percent of organic matter.

The natural subsurface constitutes a layer about 13 inches in thickness. It is a drab, plastic clay, containing 2.1 percent of organic matter.

The subsoil does not differ greatly from the surface except that it becomes lighter in color. It still retains, however, the drab or bluish color which results from a lack of the higher oxids of iron.

Treatment.—This type is usually pervious to water because of the cracking which has taken place during periods of drouth. It is difficult to work because of the danger of puddling if too wet and the formation of clods when it becomes dry. In order to maintain the best working qualities, organic matter must be added to the soil. This will make it less readily puddled, and will promote granulation. An occasional application of limestone will probably be beneficial.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to intelligently interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification here used.

The unit in the soil survey is the soil type, and each type possesses more or less definite characteristics. The line of separation between adjoining types is usually distinct, altho sometimes one type grades into another so gradually that it is very difficult to draw the line between them. In such exceptional cases, some slight variation in the location of soil-type boundaries is unavoidable.

In establishing soil types several factors must be taken into account. These are: (1) the geological origin of the soil, whether residual, cumulose, glacial, eolial, alluvial, or colluvial; (2) the topography, or lay of the land; (3) the native vegetation, as forest or prairie grasses; (4) the depth and the character of the surface, the subsurface, and the subsoil, as to the percentages of gravel, sand, silt, clay, and organic matter which they contain, their porosity, granulation, friability, plasticity, color, etc.; (5) the natural drainage; (6) the agricultural value, based upon its natural productiveness; (7) the ultimate chemical composition and reaction.

Great Soil Areas in Illinois.—On the basis of the first of the above mentioned factors, namely, the geological origin, the state of Illinois has been divided into sixteen great soil areas with respect to their geological formation. The names of these areas are given in the following list along with their corresponding index numbers, the use of which is explained below. For the location of these geological areas, the reader is referred to the general map published in Bulletins 123 and 193.

100 *Unglaciated,* comprizing three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciation
300 *Lower Illinoisan glaciation,* covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river bottom and swamp lands,* found in the older or Illinoisan glaciation
1400 *Late river bottom and swamp lands,* those of the Wisconsin and Iowan glaciations
1500 *Terraces,* formed by overloaded streams draining from the glaciers and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago or the enlarged Lake Michigan

Mechanical Composition of Soils.—The mechanical composition, or the texture, is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents:

Organic matter: undecomposed and partially decayed vegetable material

Inorganic matter: clay, silt, fine sand, sand, gravel, stones.

Classes of Soils.—Based upon the relative proportion of the various constituents mentioned above, soils may be grouped into a number of well recognized classes. Following is a list of these classes, arranged according to their index numbers, the use of which is explained below.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

Naming and Numbering Soil Types.—The naming of soil types has been the subject of much discussion, and practice varies considerably in this matter. In this soil survey of Illinois a system of classification and naming has been adopted which is based upon the various considerations presented in the preceding paragraphs.

After texture, one of the most striking characteristics of a soil is the color. Therefore, in the naming of soils in Illinois, a combination of color and texture, together with other descriptive terms when necessary, has been adopted so that the name in itself carries a definite description of a given soil type; as for example, "gray silt loam on tight clay," or "brown silt loam over gravel." The use of the prepositions *on* and *over* serves to indicate the presence of certain substrata. When the surface soil is underlain with material such as sand, gravel, or rock, the word *over* is used if this material lies at a depth greater than 30 inches; if it is less than 30 inches, the word *on* is used.

For further identification of soil types a system of numbering, resembling somewhat the Dewey library system, has been adopted whereby each soil type is assigned a certain number. This number indicates at once the geological origin of the soil as well as its physical description. The digits of the order of hundreds represent the geological area where the soil is found, beginning at 100 with the unglaciated, and following in series in the order of the enumeration presented in the paragraph above headed *Great Soil Areas In Illinois.* The digits of the orders of units and tens represent the various kinds of soil such as are enumerated above in the list of soil classes. A modification of a soil type called a *phase* is designated in this system by a figure placed at the right of the decimal point. To illustrate the working of this numbering system, suppose a soil type bears the number 726.5. The number 7 indicates that this soil occurs in the Iowan glaciation, the 26 that it is a brown silt loam, and the .5 that rock is found less than 30 inches below the surface. These numbers are especially useful in designating small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and a description of the area covered, will be found in the respective county soil reports.

SOIL SURVEY METHODS

Mapping the Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. In order that the survey be thoroly truthworthy it is necessary that careful, well-trained men be employed to do the mapping. The work is prosecuted to the best advantage by working in parties of from two to four. Only such men are placed in charge of these parties as are thoroly experienced in the work and have shown themselves to be especially well qualified in training and ability.

The men must be able to keep their location exactly and to recognize the different soil types, with their principal variations and limits, and they must show these upon the maps correctly. A definite system is employed in checking up this work. As an illustration, one man will survey and map a strip 80 rods or 160 rods wide and any convenient length, while his associate will work independently on another strip adjoining this area, and if the work is correctly done the soil-type boundaries will match up on the line between the two strips.

An accurate base map for field use is absolutely necessary for soil mapping. The base maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as a basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil-type boundaries, together with the streams, roads, railroads, canals, and town sites are placed in their proper locations upon the map while the mapper is on the area. Each section, or square mile, is divided into 40-acre plots on the map, and the surveyor must inspect every ten acres and determine the type or types of soil composing it. The different types are indicated on the map by different colors, pencils for this purpose being carried in the field.

A small auger 40 inches long forms for each man an invaluable tool with which he can quickly secure samples of the different strata for inspection. An extension for making the auger 80 inches long is taken by each party, so that any peculiarity of the deeper subsoil layers may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by an odometer attached to the axle of the vehicle or by some other measuring device, while distances in the field away from the roads are determined by pacing, an art in which the men become expert by practice. The soil boundaries can thus be located with as high a degree of accuracy as can be indicated by pencil on the scale of one inch to the mile.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. For this purpose usually three strata are sampled; namely, the surface (0 to 6⅔ inches), the subsurface (6⅔ to 20 inches), and the subsoil (20 to 40 inches). These strata correspond approximately, in the common kinds of soil, to 2,000,000 pounds of dry soil per acre in the surface layer, and to two times and three times this quantity in the subsurface and the subsoil, respectively.

By this system of sampling we have represented separately three zones for plant feeding. The surface layer includes at least as much soil as is ordinarily turned with the plow. This is the part with which the farm manure, limestone, phosphate, or other fertilizer applied in soil improvement is incorporated, and which must be depended upon in large part to furnish the necessary plant food for the production of crops. Even a rich subsoil has little or no value if it lies beneath a worn-out surface, but if the fertility of the surface soil is maintained at a high point, then the strong, vigorous plants will have power to secure more plant food from the subsurface and subsoil.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. Even tho plowed alike and at the same time, prepared the same way, planted the same day with the same kind of seed, and cultivated alike, watered by the same rains and warmed by the same sun, nevertheless the best acre may produce twice as large a crop as the poorest acre on the same farm, if not, indeed, in the same field; and the fact should be repeated and emphasized that with the normal rainfall of Illinois the productive power of the land depends primarily upon the stock of plant food contained in the soil and upon the rate at which it is liberated, just as the success of the merchant depends primarily upon his stock of goods and the rapidity of sales. In both cases the stock of any commodity must be increased or renewed whenever the supply of such commodity becomes so depleted as to limit the success of the business, whether on the farm or in the store.

CROP REQUIREMENTS

Ten different elements of plant food are essential for the growth and formation of every plant. These elements are: *carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, magnesium, calcium, and iron;* and they are represented by the chemical symbols: C, O, H, N, P, S, K, Mg, Ca, and Fe. Some seasons in central Illinois are sufficiently favorable to allow the production of at least 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. When such crops are not produced under favorable seasonal conditions, the failure is due to unfavorable soil condition, which may

TABLE A.—PLANT FOOD IN WHEAT, CORN, OATS, AND CLOVER

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain......	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat, straw.....	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain.......	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover.......	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs........	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain.......	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw........	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed.......	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay.......	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00

result from poor drainage, poor physical condition, or an actual deficiency of plant food.

Table A shows the plant-food requirements of some of our most common field crops with respect to the seven elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of any element removed from an acre of land by a crop of a given yield can easily be computed.

It needs no argument to show that the continuous removal of such quantities of plant food without provision for their replacement must result sooner or later in soil depletion.

PLANT-FOOD SUPPLY

Of the ten elements of plant food, three *(carbon, oxygen,* and *hydrogen)* are secured from air and water, and seven from the soil. *Nitrogen,* one of these seven elements obtained from the soil by all plants, may also be secured from the air by one class of plants (legumes), in case the amount liberated from the soil is insufficient; but even these plants (which include only the clovers, peas, beans, and vetches among our common agricultural plants) are dependent upon the soil for the other six elements *(phosphorus, potassium, magnesium, calcium, iron, and sulfur*), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

TABLE B.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	19
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[1]	80	8	28
Dried blood	280	...	...
Sodium nitrate	310	...	...
Ammonium sulfate	400	...	...
Raw bone meal	80	180	...
Steamed bone meal	20	250	...
Raw rock phosphate	...	250	...
Acid phosphate	...	125	...
Potassium chlorid	...	...	850
Potassium sulfate	...	...	850
Kainit	...	...	200
Wood ashes[2]	...	10	100

[1]Young second year's growth ready to plow under as green manure.
[2]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

The vast difference with respect to the supply of these essential plant food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to nearly 33,000 pounds. In like manner the phosphorus content varies from about 420 pounds to 4,900 pounds, the potassium ranges from 1,530 pounds to about 58,000 pounds. Similar variations are found in all of the other essential plant food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table B is presented for the purpose of furnishing information regarding the quantity of plant food contained in some of the materials most commonly used as sources of plant-food supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of fertility actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are limestone and decaying organic matter. Tillage also has a considerable effect in this connection.

Effect of Limestone.—Limestone corrects the acidity of the soil and thus encourages the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the insoluble and unavailable organic nitrogen into soluble and available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium, and also to dissolve the insoluble phosphate and limestone which may be applied in low-priced forms. Thus, in the conversion of sufficient organic nirogen into nitrate nitrogen for a 100-bushel crop of corn, the nitrous acid formed is alone sufficient to convert seven times as much insoluble tricalcium phosphate into soluble monocalcium phosphate as would be required to supply the phosphorus for the same crop.

Effect of Organic Matter.—Organic matter may be supplied by animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter, and by plant manures, including green-manure crops and cover crops plowed under and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant food than the 20 tons of old, inactive organic matter. The history of the individual

farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated more or less definitely by the *ratio of carbon to nitrogen.* As an average, the fresh organic matter incorporated with soils contains about twenty times as much carbon as nitrogen, but the carbohydrates ferment and decompose much more rapidly than the nitrogenous matter; and the old resistant organic residues, such as are found in normal subsoils, commonly contain only five or six times as much carbon as nitrogen. Soils of normal physical composition, such as loam, clay loam, silt loam, and fine sandy loam, when in good productive condition, contain about twelve to fourteen times as much carbon as nitrogen in the surface soil; while in old, worn soils that are greatly in need of fresh, active, organic manures, the ratio is narrower, sometimes falling below ten of carbon to one or nitrogen. Except in newly made alluvial soils, the ratio is usually narrower in the subsurface and subsoil than in the surface stratum. Soils of cut-over or burnt-over timber lands sometimes contain so much partially decayed wood or charcoal as to destroy the value of the nitrogen-carbon ratio for the purpose indicated.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing soluble phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant food by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant food is concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes: Limestone provides the plant food calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much

more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by preventing the growth of certain fungus diseases, such as corn root rot. Experience indicates that it modifies directly the physical structure of some soils, frequently to their great improvement.

Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands. Remarkable success has been experienced with limestone used in conjunction with sweet clover in the reclamation of abandoned hill land which had been ruined thru erosion.

Amounts to Apply.—If the soil is acid, at least 2 tons per acre of ground limestone should be applied as an initial treatment. Continue to apply about 2 tons per acre of ground limestone every four or five years, using preferably at times magnesian limestone ($CaCO_3MgCO_3$), which contains both calcium and magnesium and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone ($CaCO_3$). On strongly acid soils, or on land being prepared for alfalfa, 4 or 5 tons per acre of ground limestone may well be used for the first application.

How to Ascertain the Need for Limestone.—The need of a soil for limestone may be ascertained by applying the litmus-paper test for soil acidity. Along with the acidity test, a test for the presence of carbonates should be made. It should be understood that a positive test for carbonates does not guarantee the absence of acid; for it may happen, especially when the soil is near the neutral point, that positive tests for both acidity and carbonates are obtained. This condition is explained by the assumption that solid particles of calcium or magnesium carbonates form centers of alkalinity within a soil that is generally acid.

Following are the directions for making these tests:

To test for soil acidity, make a ball of fresh moist soil, break it in two, insert a piece of blue litmus paper, and press the soil firmly together again. After a few minutes examine the paper. If it has turned pink or red, soil acidity is indicated. The intensity of the color and the rapidity with which it develops indicates to some extent the amount of acidity. To make a thoro examination, samples should be tested from the surface and from the subsoil at different places in the field. Needless to say the reliability of the test depends upon the quality of litmus paper used.

To make the test for carbonates, make a shallow cup of a ball of soil and pour into it a few drops of concentrated hydrochloric acid. If carbonates are present they are decomposed with the liberation of carbon dioxid, which appears as gas bubbles, producing foaming or effervescence. With much carbonate present the action is lively, but with mere traces of it the bubbles are given off slowly. If no carbonate, or very little, is indicated by the test, then it is advisable to apply limestone.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen costs from four to

five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for agricultural uses. *These are the chemical and the biological fixation of the atmospheric nitrogen.* Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of those legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for feed and seed as well as for nitrate production, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen, the possibilities of which now represent numerous compounds, will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes.

For easy figuring it may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy requires 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpeas contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of a soil varies according to its origin and the kind of farming practiced. Even virgin soils are found that are deficient in phosphorus.

On all lands deficient in phosphorus (except on those susceptible to serious erosion by surface washing or gullying) that element should be applied in considerably larger amounts than are required to meet the actual needs of the crops desired to be produced. The abundant information thus far secured shows positively that fine-ground natural rock phosphate can be used successfully and very profitably, and clearly indicates that this material will be the most economical form of phosphorus to use in all ordinary systems of permanent, profitable soil improvement. The first application may well be one ton per acre, and subsequently about one-half ton per acre every four or five years should be applied, at least until the phosphorus content of the plowed soil reaches 2,000 pounds per acre, which may require a total application of from 3 to 5 or 6 tons per acre of raw phosphorus containing 12½ percent of the element phosphorus.

Steamed bone meal and even acid phosphate may be used in emergencies, but it should always be kept in mind that a pound of phosphorus delivered in Illinois in the form of raw phosphate (direct from the mine in carload lots), is much cheaper than the same amount in steamed bone meal or in acid phosphate, both of which cost too much per ton to permit their common purchase by farmers in carload lots, which is not the case with raw phosphate. Landowners should bear in mind the fact that phosphorus additions to the soil in amounts above the immediate crop requirements represent a permanent investment, since this element is not readily lost in the drainage water as in the case of nitrogen. It is removed from the farm thru the sale of crops, milk, and animals.

Phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the fine-ground rock phosphate be intimately mixed with the organic material as it is plowed under.

The Potassium Problem

Normal soils, in which clay and silt form a considerable part of the constituency, are well stocked with potassium, altho it exists largely in insoluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be supplied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of normal soils are concerned, that the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have practically the same power as potassium to increase crop yield in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much

potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt, kainit, was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part perhaps because the potassium removed in the crops is mostly returned in the manure if properly cared for, and perhaps in larger part because the decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no plant food of value.

In considering the conservation of potassium on the farm it should be remembered that in average live-stock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in live-stock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by the actual crop requirements for plant food, magnesium and calcium are more limited in some Illinois soils than potassium. But with these elements we must also consider the loss by leaching.

Doctor Edward Bartow and associates, of the Illinois State Water Survey, have shown that as an average of 90 analyses of Illinois well-waters drawn chiefly from glacial sands, gravels, or till, 3 million pounds of water (about the average annual drainage per acre for Illinois) contained 11 pounds of potassium, 130 of magnesium, and 330 of calcium. These figures are very significant, and it may be stated that if the plowed soil is well supplied with the carbonates of magnesium and calcium, then a very considerable proportion of these amounts will be leached from that stratum. Thus the loss of calcium from the plowed soil of an acre at Rothamsted, England, where the soil contains plenty of limestone, has averaged more than 300 pounds a year as determined by analyzing the soil in 1865 and again in 1905. And practically the same amount of calcium was found by analyzing the Rothamsted drainage waters.

Common limestone, which is calcium carbonate ($CaCO_3$), contains, when pure, 40 percent of calcium, so that 800 pounds of limestone is equivalent to 320 pounds of calcium. Where 10 tons per acre of ground limestone was applied at Edgewood, Illinois, the average annual loss during the next ten

years amounted to 790 pounds per acre. The definite data from careful investigations seems to be ample to justify the conclusion that where limestone is needed at least 2 tons per acre should be applied every four or five years.

It is of interest to note that thirty crops of clover of 4 tons each would require 3,510 pounds of calcium, while the most common prairie land of southern Illinois contains only 3,420 pounds of total calcium in the plowed soil of an acre. Thus limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals —to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of surfur, such as exists in our common types of soil, and an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply to conditions in Illinois.

Physical Improvement of Soils

In the management of most soil types, one very important thing, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is

organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is being destroyed during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, corn stalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and corn stalks should be turned under, and not burned. Probably no form of organic matter acts more beneficially in producing good tilth than corn stalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of corn stalks is one and one-half times that of a ton of manure, and a ton of dry corn stalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the corn stalks during the winter and often rather late in the spring after the frost is out of the ground. This tramping by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The bad effect will be greater if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including a liberal use of legumes, in order to increase the organic matter of the soil either by plowing under the legume crops and

other crop residues (straw and corn stalks), or by using for feed and bedding practically all the crops raised and returning the manure to the land with the least possible loss. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations, applicable to the corn belt, which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover) or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in live-stock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass.

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be seeded four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Wheat (with clover)
Second year —Corn
Third year —Oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Wheat or oats (with colver)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotation

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover especially as a green manure for building up depleted soils, as well as a pasture and hay crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields Representing the More Important Types of Soil Occurring in Peoria County)

In the earlier reports of this series it was the practice to incorporate in the body of the report the results of certain experiment fields, for the purpose of illustrating the possibilities of improving the soil of various types. The information carried by such data must, naturally, be considered more or less tentative. As the fields grow older new facts develop, which in some instances may call for the modification of former recommendations. It has therefore seemed desirable to separate this experiment field data from the more permanent information of the soil survey, and embody the same in the form of a supplement to the soil report proper, thus providing a convenient arrangement for possible future revisions as further data accumulate.

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the summarized results from certain of these fields which are representative of the types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

These fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots and each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, live-stock and grain farming. *In the live-stock system,* stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in form of plant manures, including all the plant residues produced, such as corn stalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It is the plan in this latter system to remove from the land only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the live-stock system.

Rotations

Crops which are of interest in the respective localities are grown in definite rotations, and on most of the fields provision is made so that every crop in the rotation is represented every year. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. In the event of clover failure, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—All crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application are: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, the equivalent of 200 pounds of kainit. The initial application of limestone is usually 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

BROWN SILT LOAM

Several experiment fields have been conducted on brown silt loam soil at various locations in Illinois. Those located at the University have been in operation the longest and they serve well to illustrate the principles involved in the maintenance and improvement of this type of soil.

The Morrow Plots

It happens that the oldest soil experiment field in the United States is located on typical brown silt loam of the early Wisconsin glaciation, on the campus of the University of Illinois. This field was started in 1879 by George E. Morrow, who for many years was Professor of Agriculture, and these plots are known as the Morrow plots.

TABLE 1.—URBANA FIELD, MORROW PLOTS: CROP YIELDS IN SOIL EXPERIMENTS

Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
		Corn	Corn	Oats	Corn	Oats	Clover
1879–87	None.......	....	....	....	....	....	....
1888	None.......	54.3	49.5	....	....	48.6	....
1889	None.......	43.2	....	37.4	....	....	(4.04)
1890	None.......	48.7	54.3	....	....	....	(1.51)
1891	None.......	28.6	33.2	....	....	....	(1.46)
1892	None.......	33.1	....	37.2	70.2	....	....
1893	None.......	21.7	29.6	....	34.1	....	....
1894	None.......	34.8	....	57.2	....	65.1	....
1895	None.......	42.2	41.6	....	....	22.2	....
1896	None.......	62.3	....	34.5	....	....	....
1897	None.......	40.1	47.0	....	....	....	....
1898	None.......	18.1	....	....	....	....	....
1899	None.......	50.1	44.4	....	53.5	....	....
1900	None.......	48.0	....	41.5	....	....	....
1901	None.......	23.7	33.7	....	34.3	....	....
1902	None.......	60.2	....	56.3	....	54.6	....
1903	None.......	26.0	35.9	....	....	....	(1.11)
1904	None.......	21.5	....	17.5	55.3	....	....
1904	MLP.......	17.1	....	25.3	72.7	....	....
1905	None.......	24.8	50.0	....	....	42.3	....
1905	MLP.......	31.4	44.9	....	....	50.6	....
1906	None.......	27.1	....	34.7	....	....	(1.42)[1]
1906	MLP.......	35.8	....	52.4	....	....	(1.74)[1]
1907	None.......	29.0	47.8	....	80.5	....	....
1907	MLP.......	48.7	87.6	....	93.6	....	....
1908	None.......	13.4	....	32.9	....	40.0	....
1908	MLP.......	28.0	....	45.0	....	44.4	....
1909	None.......	26.6	33.0	....	....	....	(.65)[2]
1909	MLP.......	31.6	64.8	....	....	....	(1.73)[3]
1910	None.......	35.9	....	33.8	58.6	....	....
1910	MLP.......	54.6	....	59.4	83.3	....	....
1911	None.......	21.9	28.6	....	....	20.6	....
1911	MLP.......	31.5	46.3	....	....	38.0	....
1912	None.......	43.2	....	55.0	....	....	16.3[1]
1912	MLP.......	64.2	....	81.0	....	....	20.0[1]
1913	None.......	19.4	29.2	....	33.8	....	....
1913	MLP.......	32.0	25.0	....	47.8	....	....
1914	None.......	31.6	....	33.6	....	39.6	....
1914	MLP.......	39.4	....	58.2	....	60.4	....
1915	None.......	40.0	49.0	....	....	....	24.2[1]
1915	MLP.......	66.0	81.2	....	....	....	27.1[1]
1916	None.......	11.2	....	37.5	27.8	....	....
1916	MLP.......	10.8	....	64.7	40.6	....	....
1917	None.......	40.0	48.4	....	....	68.4	....
1917	MLP.......	78.0	81.4	....	....	86.9	....
1918	None.......	13.6	....	27.2	....	....	(2.58)
1918	MLP.......	32.6	....	59.3	....	....	(4.04)
1919	None.......	24.0	30.8	....	52.2	....	....
1919	MLP.......	43.4	66.2	....	70.8	....	....
1920	None.......	28.2	....	37.2	....	52.2	....
1920	MLP.......	54.4	....	51.6	....	69.7	....

[1]Soybeans.
[2]In addition to the hay, .64 bushel of seed was harvested.
[3]In addition to the hay, 1.17 bushels of seed were harvested.

TABLE 2.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY
Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover
		16 crops	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
1888 to 1903	None.......	39.7	41.0	44.0	48.0	47.6	(2.03)
		17 crops	*8 crops*	*9 crops*	*6 crops*	*6 crops*	*3 crops*
1904 to 1920	None.......	26.6	39.6	34.4	51.4	43.9	(1.55)[1]
	MLP.......	41.1	62.2	55.2	68.1	58.3	(2.50)[1]

[1]One crop of soybean hay.

The Morrow series now consists of three plots divided into halves and the halves are subdivided into quarters. On one plot corn is grown continuously; on the second corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904, receiving standard applications of farm manure with cover crops grown in the one-crop and two-crop systems. Phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. At the same time the rate of subsequent application of both forms of phosphorus was reduced to one-fourth the quantity, or to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per year. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre with the intention of standardizing the application to the rate of 1,000 pounds of limestone per acre per year.

FIG. 1.—CORN ON THE MORROW PLOTS IN 1910

Table 1 gives the yearly records of the crop yields, and Table 2 presents the same in summarized form.

Summarizing the data from these Morrow plots into two periods with the second period beginning in 1904 when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oats production, while the averages for the three-year system show an increase in corn yield and decreases in oats and clover. Unfortunately the numbers of crops included in these last averages are too small to warrant positive conclusions.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

The Davenport Plots

Another set of plots on the University campus at Urbana, forming a more extensive series than the Morrow plots, but of more recent origin, are the Davenport plots. Here each crop in the rotation is represented every year. These plots were laid out in 1895, but special soil treatment was not begun until 1901. They now comprize five series of ten plots each, and each series constitutes a "field" in a crop rotation system.

From 1901 to 1911 three of the series were in a three-year rotation system of corn, oats, and clover, while the remaining two series rotated in corn and oats. In 1911 these two systems were combined into a five-series field, with a crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field. The alfalfa occupies one series during a rotation of the other four crops, shifting to another series in the fifth year, thus completing the cycle of all series in twenty-five years.

The soil treatment applied to these plots has been as follows:

Legume cover crops (**Le**), such as cowpeas and clover, were seeded in the corn at the last cultivation on Plots 2, 4, 6, and 8, from 1902 to 1907, but the growth was small and the effect, if any, was to decrease the returns from the regular crops.

Crop residues (**R**) have been returned to these same plots since 1907. These consist of stalks and straw, and all legumes except alfalfa hay and the seed of clover and soybeans.

Manure (**M**) was applied preceding corn, at the rate of 2 tons per acre per year in 1905, 1906, and 1907; subsequently as many tons of manure have been applied as there have been tons of air-dry produce harvested from the respective plots.

Lime (**L**) was applied on Plots 4 to 10 at the rate per acre of 250 pounds of air-slaked lime in 1902, and 600 pounds of limestone in 1903. No further application was made until 1911, when the system of cropping was changed. Since that time applications of limestone have been made at the rate of one-half ton per acre per year.

Phosphorus (**P**) was applied on Plots 6 to 9 at the rate of 25 pounds per acre per annum in 200 pounds of steamed bone meal; but beginning with 1908 rock phosphate at the rate of 600 pounds per acre per annum was substi-

TABLE 3.—URBANA FIELD, DAVENPORT PLOTS: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Ten-Year Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn	Oats	Wheat	Clover 5 crops	Soybeans 5 crops	Alfalfa
1	0	55.6	50.5	26.0	(2.42)	(1.47)	(2.43)
2	R	57.1	52.3	28.7	1.47[1]	19.8	(2.46)
3	M	66.3	61.9	28.2	(2.56)	(1.62)	(2.52)
4	RL	64.8	55.6	31.4	1.61[1]	20.3	(2.72)
5	ML	69.6	64.1	32.8	(2.90)	(1.67)	(3.03)
6	RLP	71.5	69.8	43.0	2.29[1]	23.5	(3.69)
7	MLP	73.0	68.6	40.0	(3.52)	(1.97)	(3.76)
8	RLPK	70.9	72.5	40.7	1.79[1]	25.5	(3.77)
9	MLPK	70.2	72.0	39.2	(3.40)	(2.20)	(3.73)
10	Mx5LPx5	65.9	71.4	40.6	(3.31)	(2.22)	(3.77)

[1]In addition to the clover seed, a crop of hay was harvested one year on Plots 2, 4, 6, and 8, yielding 2.38, 2.20, 2.54, and 2.39 tons, respectively.

tuted for the bone meal on one-half of each of these plots. These applications continued until 1918 when adjustments were begun, first to make the rate of application of rock phosphate four times that of the bone meal, and finally to reduce the amounts of these materials to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per annum. The usual practice has been to apply and plow under at one time all phosphorus and potassium required for the rotation.

Potassium (**K** = kalium) has been applied on Plots 8 and 9 in connection with the bone meal and rock phosphate, at the yearly rate of 42 pounds per acre, and mainly as potassium sulfate.

On Plot 10 about five times as much manure and phosphorus are applied as on the other plots, but this "extra heavy" treatment was not begun until 1906, only the usual lime, phosphorus, and potassium having been applied in previous years. The purpose in making these heavy applications is to try to determine the climatic possibilities in crop yields by removing the limitations of inadequate fertility.

It will be observed that the applications described above provide for the two rather distinct systems of farming already described. *The grain system*, in which animal manure is not produced and where the organic matter is provided by the direct return to the soil of all crop residues, is exemplified in Plots 2, 4, 6, and 8; and the *live-stock system*, in which farm manure is utilized for soil enrichment, is represented in Plots 3, 5, 7, and 9.

Table 3 shows a summary of the results obtained on the Davenport plots beginning with the year 1911, when the present cropping system was introduced.

When used in conjunction with phosphorus the crop residues and the manure appear about equally effective; but where phosphorus is not applied, the manure has been decidedly more effective, under the conditions of the experiment. It should be observed, however, in this connection, that the plowing under of clover is a very essential feature of the residues system, and that, as a matter of fact, there were five clover failures, when soybeans were substituted, during the ten years. Perhaps with a more reliable biennial legume than red clover, the results would have been more favorable for this system.

Manure
Yield: 1.43 tons per acre

Manure, limestone, phosphorus
Yield: 2.90 tons per acre

FIG. 2.—CLOVER ON THE DAVENPORT PLOTS IN 1913

By comparing Plots 2 and 3 with Plots 4 and 5, it is found that limestone has had a beneficial effect on all crops. What the financial profit amounts to depends obviously upon the market value of the crops and the cost of the limestone.

Comparing Plots 4 and 5 with Plots 6 and 7, respectively, there is found in all cases an increase in crop yield as a result of adding phosphorus. The effect on wheat is especially pronounced. Where limestone and phosphorus are applied in addition to the crop residues, an increase of 17 bushels of wheat, over the yield of the untreated land, has been obtained as a ten-year average.

The effect of adding potassium to the treatment is of much interest. Plots 8 and 9 are the same as Plots 6 and 7, respectively, except that potassium has been applied to the former. On the whole, no significant benefit is shown from the addition of potassium.

No benefit appears as the result of the extra-heavy applications of manure and phosphorus on Plot 10. In fact the corn yields are noticeably less here than on the plots receiving the normal applications of these materials.

The University South Farm

On the University South Farm, at Urbana, several series of plots devoted primarily to variety testing and other crop-production experiments are so laid out as to show the effects of certain soil treatments that have been applied.

Several different systems of crop rotation are employed and the crops are so handled as to exemplify the two general systems of farming, grain and livestock.

The summarized results presented in Table 4 represent three different systems of cropping. The first, designated as the Southwest rotation, is to be regarded as a good rotation for general practice, on this type of soil, under Illinois conditions. This is a four-field rotation of wheat, corn, oats, and clover. The second, or North-Central rotation, consisting of corn, corn, oats, and clover, represents a system very commonly practiced; and the third or South-Central rotation, consisting of corn, corn, corn, and soybeans, must be considered as a poor rotation from the standpoint of maintaining the productiveness of the land.

TABLE 4.—URBANA FIELD, SOUTH FARM: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Southwest Rotation: Series 100, 200, 400[1]: Wheat, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 9 crops	Oats[3] 9 crops	Wheat[3] 8 crops	Clover[4] 3 crops	Soybeans 7 crops
RP	62.3	51.9	41.0	1.05	17.3[5]
R	51.9	46.5	26.9	1.38	16.2[5]
M	59.7	50.2	29.1	(2.28)	(1.25)
MP	64.3	55.4	43.1	(2.86)	(1.51)
RLP	60.5	57.2	41.8	.64	16.4[5]
R	49.7	49.6	25.8	.83	14.7[5]
M	55.5	54.1	27.8	(1.71)	(1.28)
MLP	64.1	59.6	43.9	(1.77)	(1.58)

North-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Oats 9 crops	Clover 5 crops	Soybeans 4 crops
RP	56.7	51.1	56.1	.54	16.9
R	51.7	45.2	52.0	.50	16.0
M	54.9	46.7	52.1	(2.29)	(1.60)
MP	56.5	53.4	56.9	(2.73)	(1.74)

South-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Corn, Soybeans

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Corn 3d year 9 crops		Soybeans 9 crops
RP	51.9	44.0	41.3		20.0
R	45.5	39.9	35.2		19.2
M	50.1	42.1	33.5		(1.59)
MP	54.5	46.7	42.0		(1.66)

[1]Results from Series 300 and 800 are omitted on account of variation in soil type.
[2]Soybeans when clover fails.
[3]Only seven crops with limestone.
[4]Only one crop with limestone.
[5]Average of five crops.
[6]All phosphorus plots received ½ ton per acre of limestone in 1903.

TABLE 5.—COMPARING PRODUCTION OF CORN IN THREE DIFFERENT ROTATION SYSTEMS
ACRE YIELDS FROM PLOTS ON THE UNIVERSITY SOUTH FARM
Twelve-Year Average (1908-1919)—Bushels per acre

Rotation	Wheat-corn-oats-legume[1]	Corn-corn-oats-legume[2]		Corn-corn-corn-legume[3]		
Treatment	Corn	1st Corn	2d Corn	1st Corn	2d Corn	3d Corn
Organic manures	55.8	53.3	46.0	47.8	41.0	34.3
Organic manures, phosphorus	63.2	56.6	52.3	53.2	45.3	41.6

[1]Clover 3 crops, and soybeans 7 crops.
[2]Clover 5 crops, and soybeans 5 crops.
[3]Soybeans 9 crops.

On the whole, the "residues" have not returned yields quite so high as those produced by the manure treatment; but, as remarked above in the discussion of the Davenport plots, the residues system has probably been at a disadvantage thru frequent clover failures. On the North-Central rotation, where conditions seem to have been more favorable for clover, there is very little difference between the effect of manure and of residues.

Residues plowed under
Yield: 35.2 bushels per acre

Residues and rock phosphate
Yield: 50.1 bushels per acre

FIG. 3.—WHEAT ON THE UNIVERSITY SOUTH FARM IN 1911

In the rotation system in which limestone is being applied, no benefit of consequence to any of the crops except oats appears from the use of this material. The test, however, has hardly been of sufficient duration to warrant final conclusions; and furthermore, the comparison may be somewhat impaired by a possible residual effect of the small application of limestone made in 1903 to all the phosphorus plots.

The results obtained from the use of phosphorus are important because this element has been applied to these plots solely in the form of raw rock phosphate. The figures in almost every case show an increase in yield where the phosphorus has been applied, and in most cases this increase is very pronounced. The wheat is especially responsive to phosphorus.

The records furnish some interesting comparisons of corn yields produced under different systems of cropping. Table 5 gives a general summary of the corn yields only, in which the results from the residues and manure treatments are averaged together as "organic manures." The highest annual acre-yields are found where corn occurs but once in a rotation. Where corn is grown twice in succession, the annual acre-yields are less; and where corn occurs three times, there is a further reduction. Also, the first crop of corn within a rotation produces more than the second, and the second crop yields more than the third. These are useful facts for consideration in connection with problems of general farm management.

BLACK CLAY LOAM

The Hartsburg experiment field, representing black clay loam of the middle Illinoisan glaciation, is located in Logan county just east of Hartsburg. The work was begun here in 1913. There are five series of ten plots each. A crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field, is practiced. The soil treatments are as indicated in Table 6. The table also summarizes the yields, by crops, for the period during which the plots have been under full treatment.

TABLE 6.—HARTSBURG FIELD: BLACK SILT LOAM, PRAIRIE; MIDDLE ILLINOISAN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat 5 crops	Corn 8 crops	Oats 7 crops	Clover 4 crops	Soybeans 2 crops	Alfalfa 8 crops[1]
1	0	22.6	43.4	45.4	(1.98)	(1.29)	(3.30)
2	M	27.4	48.3	50.2	(2.41)	(1.64)	(3.61)
3	ML	34.2	56.9	57.9	(2.51)	(1.82)	(3.83)
4	MLP	38.2	56.0	57.3	(2.62)	(1.92)	(4.04)
5	0	33.3	46.8	43.8	.74[2]	25.8	(3.19)
6	R	34.0	58.2	55.6	1.22[2]	26.8	(3.60)
7	RL	32.0	63.7	54.9	1.32[2]	28.4	(3.28)
8	RLP	36.4	61.1	59.0	1.41[2]	26.1	(3.83)
9	RLPK	35.2	59.5	57.2	1.42[2]	26.4	(4.01)
10	0	31.7	46.7	46.9	(2.14)	(1.69)	(3.02)

[1]No residues except on last two crops.
[2]In addition to the clover seed, hay was harvested on Plots 5, 6, 7, 8, and 9 amounting to .56, 1.01, 1.11, 1.20, and 1.03 tons, respectively.

Under the conditions of these experiments, residues alone have proved to be more effective than manure alone in the production of wheat, corn, and oats.

Limestone used with manure has given such greatly increased yields as to leave no doubt about the profitableness of its use. When applied with residues however, there appears to be on the whole little advantage from the use of limestone.

Phosphorus has given good returns on the wheat crop, but with the other crops its recommendation would be doubtful. In this connection attention should be called to the fact that chemical analysis of this black clay loam type shows about 1,600 pounds of phosphorus per acre in the surface stratum, which is a relatively high content. The experience on this field seems to bear out what the analyses show.

The addition of potassium has produced a depressing effect on the yields of all grain crops, and with the alfalfa the small gain could scarcely be considered significant.

YELLOW-GRAY SILT LOAM

Yellow-gray silt loam exhibits an important variation with respect to limestone content. In some areas, altho limestone may be altogether absent in the surface stratum it is found in abundance at a short distance beneath the surface. Accordingly, variations in response to soil treatment are exhibited by different experiment fields located on this type. In view of this discrepancy it is thought well to introduce here the records of two fields, that are representative of the type but which show a marked diversity in results, one in northern Illinois and one in the southern part of the state.

The Antioch field is located on the late Wisconsin glaciation, in Lake county, close to the Wisconsin border. The field was started in 1902, with but a single series of ten plots, under a rotation of corn, corn, oats, and wheat; but beginning with 1911 the rotation has been wheat, corn, oats, and clover. It was started in order to learn as quickly as possible what effect would be produced by the addition to this type of soil of nitrogen, phosphorus, and potassium, used singly and in combination. These elements were all applied in commercial form until 1911, after which the use of commercial nitrogen was discontinued and crop residues were substituted in its place. Nitrogen was supplied in the earlier years in 800 pounds per acre of dried blood. Phosphorus is applied in 200 pounds of steamed bone meal, and potassium in 100 pounds of potassium sulfate. At the beginning, 470 pounds of slaked lime were applied; but since 1912 limestone has been applied at the rate of 1,000 pounds per acre per year.

Table 7 presents, in summarized form, the results from the Antioch field. Because of an abnormality in Plot 1, the results from this plot are not considered. The data show that phosphorus is the one element standing out prominently as producing consistently beneficial results. Potassium applied in addition to phosphorus has, on the whole, not produced profitable results. Also, the results are unfavorable for the application of limestone. Limestone, however, is abundant in the subsoil of this type in the region of this field.

The Raleigh experiment field is located on the lower Illinoisan glaciation in southern Illinois, in Saline county. This field is laid out into four series of ten plots each, under a rotation of wheat, corn, oats, and clover. The treatments, along with the summarized results, are given in Table 8.

Manure, limestone, phosphorus
Yield: 61 bushels per acre

Nothing applied
Yield: 15 bushels per acre

FIG. 4.—CORN ON RALEIGH FIELD IN 1920

The outstanding feature of these results is the effect of limestone. Altho manure alone produces a substantial increase, especially in the corn crop, when limestone is added a remarkable increase is found in all crops. A most important fact is that the organic matter can be effectively built up thru the use of crop residues, with the application of limestone, so that the crop yields are practically as high under this "grain system" of farming as where manure is used.

Phosphorus thus far has given only moderate returns in increased crop yields, but with an increasing quantity of organic matter and nitrogen it is probable that the phosphorus applications will show up more favorably on subsequent crops. As to the use of potassium, it is to be noted that aside from an increase of 5.4 bushels of corn in the residues system, the beneficial effect has not been sufficient to justify the use of this material.

In accounting for the discrepancy in the response to limestone on these two fields, the fact is to be considered that the Antioch field is located on the late Wisconsin glaciation, where the subsoil contains large quantities of limestone; while the Raleigh field represents the lower Illinoisan glaciation, the soil of which is very acid to a great depth.

In view of these variations, a general recommendation for a complete treatment for soil of this type, that will apply to all localities, cannot be given out until more information is acquired.

Fortunately, however, each farmer can determine for himself the need of limestone for his land by applying the simple tests with litmus paper and hydrochloric acid, as explained under the discussion of limestone on page 32 of the Appendix.

TABLE 7.—ANTIOCH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LATE WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 8 crops	Oats 5 crops	Wheat 4 crops	Clover seed 2 crops
1	0	23.9	32.3	15.8	.50
2	L	21.3	26.8	13.2	.30
3	LR	21.3	29.9	20.6	.33
4	LP	30.7	43.6	36.7	1.08
5	LK	23.7	27.8	19.2	.57
6	LRP	33.8	43.3	33.3	.57
7	LRK	24.3	26.9	20.8	.59
8	LPK	25.1	38.2	30.9	1.26
9	LRPK	38.3	42.6	28.0	.33
10	RPK	38.4	44.7	30.2	.67

Phosphorus, which has paid well on the Antioch field, and has given doubtful returns thus far at Raleigh, has varied considerably in its effect when used on other fields located on this same type of soil. In this situation, therefore, the present suggestion would be that each farmer might well try out phosphorus on his own land, on a limited scale, and be guided by the outcome of his experience. The low phosphorus content of the surface stratum of this soil is an indication that in a system of permanent agriculture the time is not far off when phosphorus will become a limiting element to crop production, and the wise farmer will watch carefully the indications and be ready to make timely provision for this need.

TABLE 8.—RALEIGH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LOWER ILLINOISAN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 10 crops	Oats 10 crops	Wheat 6 crops	Clover 4 crops		Soybeans 4 crops
1	0	17.3	10.4	5.8	(.26)		(.65)
2	M	29.7	13.0	7.7	(.31)		(.81)
3	ML	40.9	20.0	21.0	(1.08)		(1.08)
4	MLP	41.2	20.3	21.5	(1.32)		(1.24)
5	0	17.3	10.3	7.0	(.00)	.01[2]	2.3
6	R	20.1	12.8	8.4	(.00)	.01[2]	3.0
7	RL	34.9	21.5	18.8	(1.60)[1]	.10[2]	5.8
8	RLP	36.5	22.7	21.2	(1.61)[1]	.09[2]	6.8
9	RLPK	41.9	23.6	22.4	(1.79)[1]	.12[2]	6.0
10	0	19.6	11.6	6.5	(1.06)		(.57)

[1]One crop only (1920).
[2]Average of two crops.

YELLOW SILT LOAM

A soil fertility experiment field on yellow silt loam is located at Elizabethtown, in the southern end of the state, but this field has not been in operation long enough to furnish results that can be used.

However, some experiments in pot culture have been conducted with soil of this type, the results of which furnish useful data in indicating the proper management of this kind of soil.

In one experiment a large quantity of typical worn hill soil was collected from two different places. Each lot of soil was thoroly mixed and put into ten four-gallon jars. Wheat was planted in one series and oats in the other. Ground limestone was added to all the jars except the first and last in each set, those two being retained as control, or check pots. The elements nitrogen, phosphorus, and potassium were added singly and in combination, as shown in Table 9.

As an average, the yield produced where nitrogen was applied, was about eight times as large as that secured without the addition of nitrogen.

But there is no need whatever to purchase nitrogen, for the air contains an inexhaustible supply of it which, under suitable conditions, the farmer can draw upon, not only without cost, but with profit in the getting. Clover, alfalfa, sweet clover, cowpeas, and soybeans are worth raising not only because of their value as crops but because of their power, when properly inoculated with nitrogen-fixing bacteria, to secure nitrogen from the atmosphere.

In order to secure further information concerning the best practice in building up the nitrogen content, another experiment with pot cultures was conducted for several years with the same kind of worn hill soil as that used for wheat in the former experiment. The results are reported in Table 10.

To three pots (Nos. 3, 6, and 9) nitrogen was applied, in commercial form, at an expense amounting to more than the total value of the crops produced. In three other pots (Nos. 2, 11, and 12) a crop of cowpeas was grown during the late summer and fall and turned under before the wheat or oats were planted. Pots 1 and 8 served for important comparisons. After the second cover crop of cowpeas had been turned under, the yield from Pot 2 exceeded that from Pot 3; and in the subsequent years the green manure from legumes produced, as an average, somewhat better results than the commercial nitrogen. This experiment confirms the previous one in showing the very great need for nitrogen for the improvement of this type of soil—and it also shows that nitrogen need not be purchased but that it can be obtained from the air by growing legume crops and plowing them under as green manure. Of course the soil can be very markedly improved by feeding the legume crops to live stock and returning the resulting farm manure to the land, if legumes are grown frequently enough and if the farm manure produced is sufficiently abundant and is saved and applied with care.

As a rule, it is not advisable to try to enrich this type of soil in phosphorus, for with erosion, which is sure to occur to some extent, the phosphorus supply will be renewed from the subsoil.

Probably the best legumes for this type of soil are sweet clover and alfalfa. On soil deficient in organic matter, sweet clover grows better than almost any other legume, and the fact that it is a very deep-rooting plant makes it of value

FIG. 5.—WHEAT IN POT-CULTURE EXPERIMENT WITH YELLOW SILT LOAM OF WORN HILL LAND
The need of nitrogen (N) on this type of soil is clearly demonstrated.

TABLE 9.—CROP YIELDS IN POT-CULTURE EXPERIMENT WITH YELLOW SILT LOAM OF WORN HILL LAND
Grams per pot

Pot No.	Soil treatment applied	Wheat	Oats
1	None	3	5
2	Limestone	4	4
3	Limestone, nitrogen	26	45
4	Limestone, phosphorus	3	6
5	Limestone, potassium	3	5
6	Limestone, nitrogen, phosphorus	34	38
7	Limestone, nitrogen, potassium	33	46
8	Limestone, phosphorus, potassium	2	5
9	Limestone, nitrogen, phosphorus, potassium	34	38
10	None	3	5
Average yield with nitrogen		32	42
Average yield without nitrogen		3	5
Average gain for nitrogen		29	37

in increasing the organic matter and in preventing washing. Worthless slopes, where the land has been ruined by washing, may be made profitable as pasture by growing sweet clover. The blue grass of pastures may well be supplemented by sweet clover and alfalfa, and a larger growth obtained, because the legumes provide the necessary nitrogen for the blue grass.

To get alfalfa started well requires the liberal use of limestone, thoro inoculation with nitrogen-fixing bacteria, and a moderate application of farm manure. If manure is not available, it is well to apply about 500 pounds per acre of acid phosphate or steamed bone meal, mix it with the soil, by disking if possible, and then plow it under. The limestone (about 5 tons) should be applied after plowing and should be mixed with the surface soil in the preparation of the seed bed. The special purpose of this treatment is to give the alfalfa a quick start in order that it may grow rapidly and thus protect the soil from washing.

FIG. 6.—WHEAT IN POT-CULTURE EXPERIMENT WITH YELLOW SILT LOAM OF WORN HILL LAND
In the pots at the right, nitrogen is applied in commercial form. In the pots at the left, nitrogen is secured from the air thru the growing of legumes.

TABLE 10.—CROP YIELDS IN POT-CULTURE EXPERIMENT WITH YELLOW SILT LOAM OF WORN HILL LAND AND NITROGEN-FIXING GREEN MANURE CROPS

Grams per pot

Pot No.	Soil treatment applied	1903 Wheat	1904 Wheat	1905 Wheat	1906 Wheat	1907 Oats
1	None	5	4	4	4	6
2	Limestone, legume	10	17	26	19	37
11	Limestone, legume, phosphorus	14	19	20	18	27
12	Limestone, legume, phosphorus, potassium	16	20	21	19	30
3	Limestone, nitrogen	17	14	15	9	28
6	Limestone, nitrogen, phosphorus	26	20	18	18	30
9	Limestone, nitrogen, phosphorus, potassium	31	34	21	20	26
8	Limestone, phosphorus, potassium	3	3	5	3	7

DUNE SAND

In 1913 the University came into possession of a tract of dune sand on terrace, in Henderson county, near the Mississippi river, upon which an experiment field was laid out to determine the needs of these sand soils. This field is divided into six series of plots. Corn, soybeans, wheat, sweet clover, and rye, with a catch crop of sweet clover seeded in the rye on the residues plots, are grown in rotation on five series, while the sixth series is devoted to alfalfa. When sweet clover seeded in the wheat fails, cowpeas are substituted.

No catch of alfalfa or of sweet clover was obtained till the alfalfa drill was used in seeding. This covers the seed about one-half inch deep.

The following table indicates the kinds of treatment applied, the amounts of the materials used being in accord with the standard practice, as explained on page 41.

The data make apparent the remarkably beneficial action of limestone on this sand soil. Where limestone has been used in conjunction with crop residues, the yield of corn has been doubled. The limestone has also produced a fair crop of rye and excellent crops of sweet clover and alfalfa.

TABLE 11.—OQUAWKA FIELD: DUNE SAND, TERRACE

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 6 crops	Soy-beans[1] 5 crops	Wheat 6 crops	Sweet clover 4 crops		Rye 4 crops	Alfalfa 3 crops
1	0	14.3	(.89)	6.4	0		12.1	(.11)
2	M	18.9	(1.01)	8.1	0		13.3	(.13)
3	ML	23.4	(1.27)	9.7	(1.20)		20.1	(1.88)
4	MLP	22.2	(1.20)	10.1	(1.26)		19.5	(2.03)
					2 crops	2 crops		
5	0	14.4	3.5	7.4	(0)	0	13.7	(.14)
6	R	16.2	3.5	8.1	(0)	0	14.1	(.12)
7	RL	29.3	6.6	9.1	(1.47)	2.53	23.2	(2.05)
8	RLP	29.3	6.4	10.4	(1.39)	2.20	24.2	(1.90)
9	RLPK	32.7	6.0	9.4	(1.53)	2.84	23.7	(1.86)
10	0	11.4	(.60)	6.4	(0)		10.6	(.06)

[1] In 1918 sweet clover was killed by being cut for hay. Soybeans were seeded on these plots and the following yields obtained: .86, 1.10, 1.93, and 2.00 tons of hay per acre on Plots 1 to 4; 11.1, 9.9, 14.6, 15.8, and 16.6 bushels of seed per acre on Plots 5 to 9; and .62 ton of hay per acre on Plot 10.

This land appears to be quite indifferent to phosphorus treatment. The analysis shows, however, that the stock of phosphorus in this type of soil is not large, and it may develop as time goes on and the supply diminishes along with the production of good-sized crops, that the application of this element will become profitable.

Manure
Yield: Nothing

Manure and limestone
Yield: 4.43 tons per acre

FIG. 7.—ALFALFA ON OQUAWKA FIELD IN 1918

Altho the results show an increase of 3.4 bushels of corn from the use of potassium salts, with ordinary prices this would not be a profitable treatment. The .64 bushel gain in sweet-clover seed is the average of two crops only, and this is insufficient data upon which to base conclusions. The other crops all show negative results from the potassium application.

Experience thus far shows rye to be better adapted to this land than wheat, and both alfalfa and sweet clover thrive better than soybeans. With these two legume crops thriving so well under this simple treatment, we have promise of tremendous possibilities for the profitable culture of this land, which hitherto has been considered as practically worthless.

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 20

BUREAU COUNTY SOILS

By J. G. MOSIER, S. V. HOLT, E. VAN ALSTINE
AND F. W. GARRETT
PREPARED FOR PUBLICATION BY L. H. SMITH

URBANA, ILLINOIS, DECEMBER, 1921

IN RECOGNITION

The Soil Survey of Illinois was organized under the supervision of the late Dr. Cyril G. Hopkins. The work progressed for eighteen years under his guidance and the first eighteen soil reports bear his name as senior author. On October 6, 1919, Dr. Hopkins died in a foreign land in the service of the American Red Cross. It is the purpose to carry on to completion this great work of the Illinois Soil Survey in the spirit, and along the same general plan and lines of procedure, in which it was begun.

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1921

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INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or land owner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and land owner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

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SUPPLEMENT

BUREAU COUNTY SOILS

By J. G. MOSIER, S. V. HOLT, E. VAN ALSTINE, and F. W. GARRETT
Prepared for Publication by L. H. SMITH[1]

FORMATION

Bureau county is located in the west central-northern part of Illinois, the northwest corner being about twenty-six miles from the Mississippi river. There is much variation in the soils, due to the many agencies that have been instrumental in their formation. The northwestern part of the county is in the sand and gravel terrace formed by the Rock and Green rivers. An extension of this terrace to the southeast that reaches to Bureau creek without doubt indicates a former connection between the Rock and Illinois rivers.

During the Glacial period snow and ice accumulated in the region of Labrador and to the west of Hudson Bay to such an amount that the mass pushed outward from these centers, especially southward, until a point was reached where it melted as rapidly as it advanced. In moving across the country from the far north the ice gathered up all sorts and sizes of material, including clay, silt, sand, gravel, and boulders. Some of these materials were carried for hundreds of miles and rubbed against surface rocks and against each other, producing large quantities of rock flour. When, thru the melting of the ice, the limit of advance was reached, the material carried by the glacier was deposited, accumulating in a broad undulating ridge or moraine. When the ice melted more rapidly than the glacier advanced, the terminus of the glacier would recede and the material would be deposited somewhat irregularly over the area previously covered.

THE GLACIATIONS OF BUREAU COUNTY

During the Glacial period there were six distinct and separate glacial advances as follows, in order of their occurrence:

(1) The Nebraskan, which did not touch Illinois. (2) The Kansan, which covered parts of Hancock and Adams counties. The Weymouth soil was developed from the surface of the Kansan glacial material. (3) The Illinoisan, which covered all of the state except the northwest corner (practically all of Jo Daviess county), the southern part of Calhoun county, and the seven southernmost counties. The Sangamon soil was formed from the surface of the Illinoisan drift. (4) The Iowan, which covered a part of northern Illinois. The area covered by this advance is difficult to determine because of the later glaciations. At about the close of the Iowan glacial advance, loess or wind deposits were made. The surface of this material was formed into the Peorian soil, which was buried by the early Wisconsin glaciation. (5) The early Wisconsin glaciation, which covered the northeastern part of the state as far west as Peoria and

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south to Shelbyville. (6) The late Wisconsin glaciation, which extended to the west line of McHenry county and south to the town of Milford in Iroquois county.

Only three of these glacial advances covered all or part of Bureau county, burying the old soils and producing new ones. The first of these was the Illinoisan glacier, which probably covered the entire county. Subsequent glaciers covered most of this deposit leaving the Illinoisan drift exposed only in the southwestern part of the county, including Towns 15 North, Ranges 6 and 7 East, and the western tier of sections in Town 14 North, Range 8 East. A system of moraines extends across the first two townships and marks the northern limit of the exposed Illinoisan drift. The Illinoisan glacier was followed by the Iowan, which covered most of the county north of Town 15 North. Nearly all of the Iowan drift, however, has been covered by a subsequent glacier. The map, page 3, shows the approximate area of the Iowan glaciation now exposed.

The latest glacial advance that reached this county was the early Wisconsin, which covered the eastern two-thirds of the county and built up a very extensive moraine known as the Bloomington morainic system. This forms the ridge upon which Providence and Milo are located. This moraine extends to the northward and forms the divide between the Rock and the Illinois rivers. In the northeast part of the county the Bloomington system is formed by two ridges, an outer or western, and an inner or eastern ridge, the latter of which passes out at the northeast corner of the county. The Illinoisan moraine in the southwestern part of the county extends southeastward and merges with the Bloomington moraine. A fourth glaciation, the late Wisconsin, did not reach the county, but the water from the melting ice and the sediment which it carried down the Rock river undoubtedly played an important part in the formation of new soils and the modification of the old ones in the northwestern part of the county.

The material transported by the glacier varied with the character of the rocks over which it passed. Granites, limestones, sandstones, shales, etc., were encountered by the glacier, and both large and small masses of these were torn from their resting places by the enormous denuding power of the ice, ground up more or less together, and moved along with the glacier and later deposited as the ice melted. A pressure of forty pounds per square inch is exerted by a mass of ice one hundred feet thick, and these ice sheets were hundreds and possibly thousands of feet in thickness. The ice, together with the boulders and pebbles carried in it, thus became a powerful agent for grinding and wearing away the surface over which it passed. Ridges and hills were rubbed down, valleys were filled with the debris, and the surface features were changed entirely. When the ice melted, this material was deposited, and it is known as boulder clay, till, glacial drift, or simply drift.

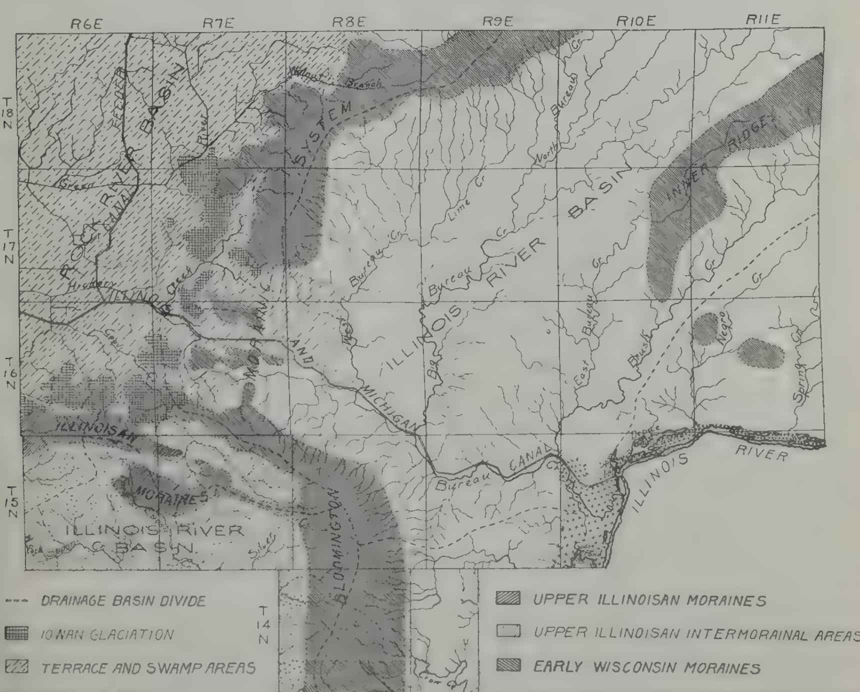
The thickness of this deposit in Bureau county varies from a few feet to about 600 feet, the greatest depth being in the old valley thru which the Rock river is supposed to have reached the Illinois. The average depth of drift in this county is at least 200 feet, and may possibly be as much as 300 feet. In many places strata of sand occur in the glacial drift. Old soils and fragments of trees are frequently encountered in the drift at depths as great as 130 feet. These soils represent interglacial periods when the glaciers receded, during

which ordinary conditions prevailed. It is believed that the drift in this county is deeper than any other in the state. The till, especially at a few feet in depth, is of a bluish color, and is commonly designated as blue clay.

PHYSIOGRAPHY AND DRAINAGE

Bureau county varies in topography from hilly to flat. These variations are due: first, to deposition of material transported by streams; second, to irregular deposition of material carried by glaciers; third, to material piled up by the wind, giving a dune topography; and fourth, to erosion by streams. The material deposited by streams gives rise to flat or very slightly undulating flood plains or older terrace deposits. These are found principally along the Illinois river, Bureau creek, and the Green river. In some cases the terrace deposits are slightly rolling, owing probably to the deposition of bars in broad, rather strong, currents of water.

The peculiar topography of glacial areas is due to the fact that the drift material was not uniformly distributed thruout the mass of ice, and when the ice melted it left the material in irregular heaps. The morainic areas are characterized by a peculiar billowy topography produced by the irregular piling up of material at the end of the glacier and by the covering up of ice masses in the moraines which, when they melted, produced depressions. The intermorainic areas vary in topography to a slight extent, giving a gently rolling character to the land.



MAP SHOWING THE DRAINAGE BASINS OF BUREAU COUNTY WITH MORAINAL, TERRACE, BOTTOM-LAND, AND SWAMP AREAS

The dune topography occurs in the northwestern part of the county within the terrace area and on the adjacent uplands. The terrace, during the time of the melting glacier, was largely covered by water and received deposits of gravel, sand, and finer material. Much of the sand and silt was reworked by the wind and piled up into dunes. The erosion topography occurs along nearly all streams outside of the terrace area. The east side of the Bloomington moraine in the southern part of the county is rather badly eroded by a large number of small streams.

There are three rather distinct drainage areas in the county: one in the southwestern part (the Spoon river basin, which is a part of the Illinois basin); one in the northwestern part (the Green river basin, which is really a part of the Rock river); and one in the eastern and southeastern part, which drains either directly into the Illinois river or into Bureau creek, which flows into the Illinois. Approximately two-thirds of the county is in this last drainage area. The county originally contained a large area of swamp land that has recently been drained into the Green river by means of dredge ditches.

The altitudes of some places in Bureau county are as follows: Arlington, 762 feet; Buda, 767; Bureau Junction, 480; Casbeer, 746; Depue, 472; Green Oak, 725; Ladd, 653; La Moille, 803; Malden, 705; Manlius, 795; Milo, 885; Mineral, 636; Neponset, 829; New Bedford, 650; Ohio, 917; Princeton, 718; Providence, 975; Spring Valley, 465; Sheffield, 671; Tiskilwa, 519; Van Orin, 807; Walnut, 714; Wyanet, 656; Yorktown, 638; Zearing, 761.

The highest point recorded in Bureau county occurs on the Bloomington moraine northeast of Providence, where the land rises to 987 feet above sea level. About a mile north of the village of Ohio the same moraine attains a height of approximately 940 feet. The lowest point in the county is 431 feet, giving a range of 556 feet in altitude. The Bloomington moraine, representing the outer edge of the Wisconsin till sheet, has a number of points over 900 feet in height. To the east of this moraine the drop is somewhat gradual until a height of approximately 750 feet is reached, while to the west of this moraine the drop reaches 650 feet. This gives about 100 feet more of relief to the west than to the east. One decided break occurs in the moraine, thru which the canal passes at the present time and which at one time formed the valley thru which the Rock river probably flowed to the Illinois.

SOIL MATERIAL AND SOIL TYPES

Altho the county has been largely covered by glaciers, the glacial drift does not constitute any large part of the material from which the soils have been derived directly. The county has been covered by a stratum of wind-blown or loessial material that varies from four to twelve feet or more in thickness. This constitutes the material from which the soil has been formed. In the terrace region in the northwest part of the county, the streams have mixed this to a greater or less extent with material, often coarser, that has been carried and deposited by them.

In general, the loessial material is deeper on the Illinoisan and Iowan drift, because, being older, there has been more time for deposition. It is also deeper on the flat areas than on the rolling ones because of the fact that erosion has removed much from the rolling land, in some cases leaving the glacial drift ex-

TABLE 1.—SOIL TYPES OF BUREAU COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (200, 500, 700, 900, 1100)			
-26	Brown silt loam	461.56	295,398	53.41
-60	Brown sandy loam	20.21	12,934	2.34
-20	Black clay loam	1.53	979	.18
-25	Black silt loam	7.52	4,813	.87
-28	Brown-gray silt loam on tight clay	.13	83	.01
-81	Dune sand	.25	160	.03
-90	Gravelly loam	1.57	1,005	.18
		492.77	315,372	57.01
	(b) Upland Timber Soils (200, 500, 700, 900, 1100)			
-34	Yellow-gray silt loam	78.37	50,157	9.07
-35	Yellow silt loam	56.88	36,403	6.58
-64	Yellow-gray sandy loam	.21	134	.02
		135.46	86,694	15.67
	(c) Terrace Soils (1500)			
1527	Brown silt loam over gravel	59.65	38,176	6.90
1560	Brown sandy loam	27.94	17,882	3.24
1561	Black sandy loam	13.48	8,627	1.56
1581	Dune sand	10.79	6,906	1.25
1550	Black mixed loam	3.93	2,515	.46
1525	Black silt loam	4.92	3,149	.57
1564	Yellow-gray sandy loam	4.96	3,174	.58
1571	Brown fine sandy loam	1.82	1,165	.21
1520	Black clay loam	.66	422	.08
1568	Brown-gray sandy loam on tight clay	2.44	1,562	.28
1536	Yellow-gray silt loam over gravel	3.31	2,118	.38
1564.4	Yellow-gray sandy loam on gravel	.33	211	.04
1560.4	Brown sandy loam on gravel	.12	77	.01
1528	Brown-gray silt loam on tight clay	.17	109	.02
1590	Gravelly loam	.17	109	.02
		134.69	86,202	15.60
	(d) Swamp and Bottom-Land Soils (1300, 1400)			
1354 / 1454	Mixed loam	39.81	25,478	4.61
1401	Deep peat	10.00	6,400	1.16
1402	Medium peat on clay	3.22	2,061	.37
1410	Peaty loam	17.07	10,925	1.98
1420	Black clay loam	.25	160	.02
1425	Black silt loam	6.82	4,365	.79
1426	Deep brown silt loam	12.90	8,256	1.49
1450	Black mixed loam	.66	422	.08
1461	Black sandy loam	8.76	5,606	1.01
		99.49	63,673	11.51
	Water	1.82	1,165	.21
	Total area of county	864.23	553,106	100.00

posed. The various agencies that have been at work in the formation and transportation of soil material necessarily give the soils of the county a varied character. In addition to the transporting agencies, the accumulation of organic matter has gone on in the swamps and, to a slightly less extent, upon the uplands, and this together with the mineral material, has added to the complexity of the soils.

Many of the smaller streams originally did not have distinct channels, but flowed sluggishly in broad shallow valleys, or "sloughs." In some cases the streams flowing into these from the upland were sufficiently swift to transport fine gravel and coarse sand, while in other cases nothing but the finer material was carried. This has given rise to soils that contain some gravel and sand in areas where normally only fine material would be found.

The soils of Bureau county are divided into the following classes:

(a) Upland Prairie Soils.—These are rich in organic matter. This land was originally covered with prairie grasses, the partly decayed roots of which have been the source of the organic matter. The flat prairie land contains a higher amount of this constituent than the undulating or rolling prairie, because the grasses and roots grew more luxuriantly there, and the higher moisture content retarded their decay.

The upland prairie soils include some areas of recent timber growth where certain kinds of trees have spread over the prairie, but this forestation has not been of sufficient duration to produce the characteristic timber soils. These areas, of greater or less width, are found along the border of most timber tracts, so that the timber actually extended a little farther than the soil type indicates.

(b) Upland Timber Soils.—These include a large part of the upland that was formerly covered with forests. These soils contain much less organic matter than the prairie soils, because the large roots of dead trees added but little, and the surface accumulations of leaves, twigs, and fallen trees were burned by forest fires or suffered almost complete decay. The timber lands are divided chiefly into two subclasses—the undulating and the hilly areas.

(c) Terrace Soils.—These include bench lands, or second bottom lands. They were formed by deposition from streams overloaded with coarse sediment during the melting of the glacier and subsequently. Finer deposits which were later made upon the coarse gravelly material now constitute the soil.

(d) Late Swamp and Bottom-Land Soils.—These include the present overflow lands, or flood plains of streams, and the very poorly drained lowlands, where peats and peaty loams have been formed.

Table 1 gives the area of each type of soil in Bureau county, and its percentage of the total area. The accompanying map shows the location and boundary of each type of soil, even when the type covers but a few acres.

INVOICE OF PLANT FOOD IN BUREAU COUNTY SOILS

SOIL ANALYSIS

The composition reported in the accompanying tables is, for the more extensive types, the average of several analyses. These analyses show that soils, like most things in nature, are variable; but for general purposes the average may be considered sufficient to characterize the soil type.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed, but it should be understood that the rate of liberation, as explained in the Appendix, page 41, is governed by many factors.

THE SURFACE SOIL

In Table 2 are reported the amount of organic carbon (the best measure of the organic matter) and the total amounts of the six important elements of plant food—nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium—contained in 2 million pounds of the surface soil of each type in Bureau county. Because of the inadequacy of information furnished by mere averages with respect to limestone content and soil acidity, these figures are not included in the tabulated results. For a more complete explanation of this point see note in the tables.

The variation among the different types of soil with respect to their content of important plant-food elements is very marked. For example, the deep peat contains, in the plowed soil of an acre, 22 times as much nitrogen as the dune sand, but it carries only one-fourth as much potassium as the brown silt loam. Similar variations are found with respect to the other elements.

It is important to note that some of the plant-food elements are present in very limited quantities as compared with crop requirements. Some simple computations are of interest in this connection. Take, for example, a four-field crop rotation of wheat, corn, oats, and clover. Assuming yields of 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover, it will be found that the most common soil of Bureau county, the brown silt loam of the prairie, does not contain more than enough total nitrogen in the plowed soil for the production of such yields for nine rotations (36 years), and the other extensive upland soils in the county are even poorer in this element.

With respect to phosphorus the condition differs only in degree. The brown silt loam contains no more of this element than would be required for fifteen crop rotations if such yields were secured as are suggested above. On the other hand, the potassium in the surface layer of this common soil type is sufficient for about 25 centuries if only the grain is sold, or for about 400 years even if the total crops should be removed and nothing returned.

These general statements relating to the total quantities of these plant food materials in the plowed soil of the most prevalent type in the county certainly emphasize the fact that the supplies of some of these necessary elements of fertility are extremely limited when measured by the needs of large crop yields for even one or two generations of people.

THE SUBSURFACE AND SUBSOIL

In Tables 3 and 4 are recorded the amounts of plant food in the subsurface and the subsoil of the different types of soil in Bureau county. It should be remembered, however, that these supplies are of little value unless the top soil is kept rich. These tables also show great stores of potassium and only limited amounts of nitrogen and phosphorus, in agreement with the data for the surface stratum presented in Table 2.

TABLE 2.—PLANT FOOD IN THE SOILS OF BUREAU COUNTY, ILLINOIS: SURFACE SOIL
Average pounds per acre in 2 million pounds of surface soil (about 0–6 ⅔ inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone and soil acidity
	(a) Upland Prairie Soils (200, 500, 700, 900, 1100)								
-26	Brown silt loam	56 440	4 810	1 190	800	31 820	8 160	13 220	
-60	Brown sandy loam	27 190	2 390	670	580	21 890	4 600	6 140	
-20	Black clay loam	85 520	7 760	2 460	1 620	28 660	12 920	24 240	
-25	Black silt loam	117 780	9 340	2 340	1 780	29 520	11 260	25 520	
-28, 1528	Brown-gray silt loam on tight clay	47 340	4 420	1 420	980	32 160	5 020	8 760	
-81	Dune sand	12 420	1 020	480	260	17 280	3 720	5 480	
-90, 1590	Gravelly loam	25 040	2 600	760	780	31 840	47 520	91 420	
	(b) Upland Timber Soils (200, 500, 700, 900, 1100)								
-34	Yellow-gray silt loam	40 480	3 910	1 240	700	32 200	5 960	12 050	
-35	Yellow silt loam	25 900	2 320	730	560	35 610	4 930	9 480	
-64	Yellow-gray sandy loam	18 360	1 440	460	380	23 260	3 360	6 080	
	(c) Terrace Soils (1500)								
-27	Brown silt loam over gravel	46 620	4 070	1 040	800	31 030	8 130	12 610	
-60	Brown sandy loam	36 100	3 080	1 000	860	22 540	4 800	8 100	
-61	Black sandy loam	74 640	7 100	1 560	1 080	22 400	7 700	19 500	
-81	Dune sand	13 940	1 160	780	320	18 660	4 340	9 340	
-50	Black mixed loam	121 340	11 780	2 500	1 620	17 040	16 020	172 300	
-25	Black silt loam	109 860	11 200	2 700	1 840	28 100	17 810	72 580	
-64	Yellow-gray sandy loam	28 020	2 160	980	640	29 160	4 780	10 980	
-71	Brown fine sandy loam	50 720	4 160	1 180	640	27 720	5 340	9 500	
-20, 1420	Black clay loam	86 560	7 240	2 520	1 360	31 580	14 740	25 600	
-68	Brown-gray sandy loam on tight clay	40 240	3 410	970	650	24 880	4 210	9 510	

In connection with these tabulated data it should be explained that the figures on limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm, and even from field to field. Therefore no at-

TABLE 2.—PLANT FOOD IN THE SOILS OF BUREAU COUNTY, ILLINOIS: SURFACE SOIL, *Concluded*

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(c) Terrace Soils (1500), *Concluded*							
-36	Yellow-gray silt loam over gravel	18 880	1 920	760	700	33 420	7 200	11 340
-64.4	Yellow-gray sandy loam on gravel	20 020	1 640	620	660	31 820	3 680	6 380
-60.4	Brown sandy loam on gravel	22 900	1 680	680	480	25 900	3 520	5 400
-28, 228, 528, 1128	Brown-gray silt loam on tight clay	47 340	4 420	1 420	980	32 160	5 020	8 760
-90, 290, 790, 990, 1190	Gravelly loam	25 040	2 600	760	780	31 840	47 520	91 420
	(d) Swamp and Bottom-Land Soils (1300, 1400)							
-54	Mixed loam	56 390	5 170	1 720	810	41 240	10 380	16 590
-01	Deep peat[1]	253 590	22 630	1 820	3 800	8 080	7 150	26 110
-02	Medium peat on clay[1]	257 570	22 650	1 500	3 250	6 420	5 670	27 770
-10	Peaty loam	152 250	13 920	1 620	1 080	20 600	9 780	44 540
-20, 1520	Black clay loam	86 560	7 240	2 520	1 360	31 580	14 740	25 600
-25	Black silt loam	155 000	13 960	2 540	2 860	26 620	12 660	34 680
-26	Deep brown silt loam	86 740	7 220	2 080	1 460	41 960	12 840	43 520
-50	Black mixed loam	105 160	10 160	1 800	1 120	24 600	5 500	16 000
-61	Black sandy loam	114 920	11 000	1 900	2 180	25 260	12 200	33 240

Limestone and soil acidity: [No at]tempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, page 43.

[1]Amounts reported are for 1 million pounds of deep peat and medium peat.

TABLE 3.—PLANT FOOD IN THE SOILS OF BUREAU COUNTY, ILLINOIS: SUBSURFACE SOIL
Average pounds per acre in 4 million pounds of subsurface soil (about 6⅔–20 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phos-phorus	Total sulfur	Total potas-sium	Total magne-sium	Total calcium	Limestone and soil acidity
	(a) Upland Prairie Soils (200, 500, 700, 900, 1100)								
-26	Brown silt loam	61 750	5 450	3 060	1 170	64 900	20 560	23 160	
-60	Brown sandy loam	35 130	3 170	1 230	910	48 990	11 770	11 160	
-20	Black clay loam	79 480	7 480	3 240	1 760	62 160	28 520	44 760	
-25	Black silt loam	112 280	7 880	3 720	1 280	57 760	18 720	37 440	
-28, 1528	Brown-gray silt loam on tight clay	39 480	4 040	1 760	11 560	69 960	12 080	20 440	
-81	Dune sand	14 080	1 040	720	440	31 920	6 480	10 920	
-90, 1590	Gravelly loam	26 840	2 680	1 600	1 520	66 160	129 840	283 920	
	(b) Upland Timber Soils (200, 500, 700, 900, 1100)								
-34	Yellow-gray silt loam	23 010	2 680	1 560	660	67 120	21 250	21 230	
-35	Yellow silt loam	13 620	1 580	1 400	740	75 940	16 760	22 040	
-64	Yellow-gray sandy loam	14 040	1 240	880	240	41 800	6 660	10 200	
	(c) Terrace Soils (1500)								
-27	Brown silt loam over gravel	60 350	5 390	1 840	1 640	64 870	18 890	21 990	
-60	Brown sandy loam	38 480	3 560	1 640	1 200	50 080	11 000	15 320	
-61	Black sandy loam	50 760	5 040	2 400	1 040	49 680	18 320	34 120	
-81	Dune sand	18 400	1 600	1 480	560	35 360	7 040	16 880	
-50	Black mixed loam	89 720	8 200	3 160	920	36 640	41 160	345 360	
-25	Black silt loam	184 880	15 960	4 840	2 400	50 680	35 380	122 440	
-64	Yellow-gray sandy loam	16 040	1 960	1 840	1 000	65 440	14 560	16 080	
-71	Brown fine sandy loam	44 400	3 880	1 680	600	60 320	11 760	16 800	
-20, 1420	Black clay loam	98 440	8 240	3 920	1 680	67 640	26 960	44 600	
-68	Brown-gray sandy loam on tight clay	33 420	3 040	1 460	1 000	54 180	10 740	16 480	

In connection with these tabulated data it should be explained that the figures on limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm, and even from field to field. Therefore no at-

TABLE 3.—PLANT FOOD IN THE SOILS OF BUREAU COUNTY, ILLINOIS: SUBSURFACE SOIL, *Concluded*

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone and soil acidity
	(c) Terrace Soils (1500), *Concluded*								
-36	Yellow-gray silt loam over gravel	13 560	1 960	2 040	920	68 680	20 200	22 280	tempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, page 43.
-64.4	Yellow-gray sandy loam on gravel	11 520	1 080	1 400	480	65 560	9 040	12 160	
-60.4	Brown sandy loam on gravel	26 760	2 320	1 400	840	53 320	7 720	9 800	
-28, 228, 528, 1128	Brown-gray silt loam on tight clay	39 480	4 040	1 760	11 560	69 960	12 080	20 440	
-90, 290, 790, 990, 1190	Gravelly loam	26 840	2 680	1 600	1 520	66 160	129 840	283 920	
	(d) Swamp and Bottom-Land Soils (1300, 1400)								
-54	Mixed loam	82 460	7 640	3 000	1 480	83 680	26 560	40 920	
-01	Deep peat[1]	506 730	45 070	3 230	7 980	12 600	12 780	56 670	
-02	Medium peat on clay[1]	226 300	20 480	1 860	2 960	20 800	11 980	47 520	
-10	Peaty loam	89 080	7 540	1 820	1 960	41 300	8 420	220 120	
-20, 1520	Black clay loam	98 440	8 240	3 920	1 680	67 640	26 960	44 600	
-25	Black silt loam	113 040	10 520	4 280	2 520	53 680	32 080	83 000	
-26	Deep brown silt loam	98 280	8 400	3 240	1 760	77 640	34 520	78 560	
-50	Black mixed loam	105 400	9 840	2 520	960	50 640	6 720	26 280	
-61	Black sandy loam	98 680	9 520	3 000	1 800	57 640	29 320	56 960	

[1]Amounts reported are for 2 million pounds of deep peat and medium peat.

TABLE 4.—PLANT FOOD IN THE SOILS OF BUREAU COUNTY, ILLINOIS: SUBSOIL

Average pounds per acre in 6 million pounds of subsoil (about 20-40 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phos-phorus	Total sulfur	Total potas-sium	Total magne-sium	Total calcium	Limestone and soil acidity
	(a) Upland Prairie Soils (200, 500, 700, 900, 1100)								
-26	Brown silt loam	26 330	3 040	2 690	1 140	97 940	42 630	51 460	In connection with these tabulated data it should be explained that the figures on limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm, and even from field to field. Therefore no at-
-60	Brown sandy loam	20 180	1 560	1 420	980	68 060	16 440	17 700	
-20	Black clay loam	26 280	2 760	3 540	420	99 180	43 380	47 880	
-25	Black silt loam	43 260	3 240	3 360	1 020	78 180	66 300	109 560	
-28 } 1528 }	Brown-gray silt loam on tight clay	21 360	2 880	2 340	600	96 180	33 120	35 820	
-81	Dune sand	9 900	540	1 020	900	50 100	12 480	17 940	
-90 } 1590 }	Gravelly loam	14 820	1 740	2 280	1 440	102 840	239 340	517 140	
	(b) Upland Timber Soils (200, 500, 700, 900, 1100)								
-34	Yellow-gray silt loam	18 710	2 460	3 050	930	99 090	41 500	36 930	
-35	Yellow silt loam	12 930	2 070	2 910	900	122 790	41 340	33 180	
-64	Yellow-gray sandy loam	11 280	840	1 140	300	55 920	9 180	12 180	
	(c) Terrace Soils (1500)								
-27	Brown silt loam over gravel	33 440	3 500	2 620	1 420	94 840	35 780	39 500	
-60	Brown sandy loam	18 420	2 160	1 680	1 320	57 960	14 280	19 140	
-61	Black sandy loam	31 800	3 360	3 240	1 440	82 980	36 480	61 920	
-81	Dune sand	15 960	1 200	2 040	780	55 140	14 280	20 220	
-50	Black mixed loam	40 740	3 600	3 600	60	80 940	45 360	164 100	
-25	Black silt loam	64 260	8 880	5 300	1 740	81 540	59 590	193 980	
-64	Yellow-gray sandy loam	18 900	1 500	2 400	1 020	68 460	18 420	19 560	
-71	Brown fine sandy loam	23 820	2 040	1 800	1 080	83 700	18 840	27 060	
-20 } 1420 }	Black clay loam	51 780	5 100	4 320	1 920	104 640	43 080	53 940	
-68	Brown-gray sandy loam on tight clay	20 220	1 890	2 220	1 170	69 720	18 450	22 320	

TABLE 4.—PLANT FOOD IN THE SOILS OF BUREAU COUNTY, ILLINOIS: SUBSOIL, *Concluded*

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone and soil acidity
	(c) Terrace Soils (1500), *Concluded*								
-36	Yellow-gray silt loam over gravel	12 420	2 100	3 660	1 380	94 080	34 320	33 300	tempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, page 43.
-28, 228, 528, 1128	Brown-gray silt loam on tight clay	21 360	2 880	2 340	600	96 180	33 120	35 820	
-90, 290, 790, 990, 1190	Gravelly loam	14 820	1 740	2 280	1 440	102 840	239 340	517 140	
	(d) Swamp and Bottom-Land Soils (1300, 1400)								
-54	Mixed loam	51 480	4 890	3 600	1 140	114 180	80 850	155 580	
-01	Deep peat[1]	555 780	46 150	3 800	11 490	19 340	24 270	235 100	
-02	Medium peat on clay	366 940	5 820	3 240	1 800	60 540	39 330	625 860	
-10	Peaty loam	51 900	3 960	2 370	1 410	62 850	57 450	307 950	
-20, 1520	Black clay loam	51 780	5 100	4 320	1 920	104 640	43 080	53 940	
-25	Black silt loam	100 980	4 140	4 320	1 740	81 780	77 400	245 280	
-26	Deep brown silt loam	50 640	4 920	3 540	1 500	112 260	108 240	201 720	
-50	Black mixed loam	62 340	4 680	4 620	300	73 980	15 420	42 840	
-61	Black sandy loam	54 960	4 680	4 560	1 320	93 240	57 060	157 260	

[1]Amounts reported are for 3 million pounds of deep peat.

DESCRIPTION OF INDIVIDUAL SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of Bureau county cover 492.77 square miles, or 57.01 percent of the area of the county. They are usually either brown or black in color, owing to the large organic-matter content. They occupy the less rolling, but not swampy, areas.

Brown Silt Loam (226, 526, 726, 926, 1126)

The brown silt loam is the most important as well as the most extensive type in Bureau county. It covers an area of 461.56 square miles, or 53.41 percent of the area of the entire county. This type occupies the slightly undulating to rolling areas of the prairie land, both morainal and intermorainal. The irregularities are due in a slight measure to erosion, but primarily to irregular deposition of material by the glaciers. While surface drainage is generally good, there are many places where the use of tile is necessary to remove the excess of water, and it is doubtless true that tile could be advantageously used to a greater extent than it is being used at present.

The soil is formed from a wind-blown or loessial material which covers the region to a depth of from two to twelve feet, the deeper deposit being over the Illinoisan and Iowan drift sheets. This material is mostly composed of the different grades of silt, the soil constituent intermediate in fineness. Altho brown silt loam is normally a prairie soil, yet in some limited areas forests have recently invaded it. They have not, however, changed it materially. These forests consist largely of black walnut, wild cherry, hackberry, ash, hard maple, and elm. A black-walnut soil is recognized generally by farmers as being one of the best timber soils because of the fact that it still contains a large amount of organic matter, characteristic of prairie soils. After the growth of several generations of trees, the organic matter may become so reduced that the soil would then be classed as a timber type.

The surface soil, 0 to 6⅔ inches, is a brown silt loam varying on the one hand to black as it grades into black clay loam (1120), or black silt loam (1125), and on the other hand to grayish brown or yellowish brown as it grades into the timber types. It contains a sufficient amount of the coarser constituents (coarse silt and fine sand) to make it work easily and yet enough fine silt and clay to give it stability and cause it to granulate. Where the brown silt loam occurs near the sandy loam, the type contains some sand and it may even include small areas of sandy loam that are not large enough to be shown on the map. It contains from 65 to 80 percent of silt, 10 to 15 percent of clay, and 15 to 30 percent of sand.

The organic-matter content varies from 3.7 to 6.6 percent, with an average of 5.2 percent, or 52 tons per acre. In the more rolling morainal areas there is less organic matter than in the low, richer, and poorly drained parts, the larger moisture content of the latter encouraging a ranker growth of grasses and roots and at the same time furnishing more favorable conditions for their pres-

ervation. The organic matter becomes less where the type grades into the yellow-gray silt loam (534, 934, and 1134).

The natural subsurface stratum varies from 9 to 16 inches in thickness, and from a dark brown or even black to a yellowish brown silt loam. Both color and depth vary with the topography, the type being lighter and shallower on the more rolling areas. Both the surface and subsurface are lighter in color where the type grades into the yellow-gray silt loam. The subsurface as sampled (6⅔ to 20 inches) contains 3.1 percent of organic matter, or 62 tons per acre. The natural subsurface is thicker in the lower, heavier, and poorly drained areas. This condition is due to the fact that deep cracks form in these low areas during periods of drouth, which allow some of the dark surface soil to be washed down by the rains, thus producing a deep layer of black soil.

The natural subsoil begins at a depth of 12 to 22 inches. It is a yellow or drabbish clayey silt or silty clay, somewhat plastic when wet. Where the drainage has been good, the color varies from a pale to a bright yellow, but where drainage has been poor it approaches a drab or an olive with pale yellow mottlings or a yellow with mottlings of drab, due to a lack of oxidation of iron.

The layer of loessial material is so deep that the drift rarely forms any part of the subsoil to a depth of 40 inches. Variations of the subsoil occur in limited areas adjacent to the sandy loam, and are due to the presence of more or less sand in the subsoil. In some small areas the subsoil passes into sand, indicating a sand deposit before the loess was deposited.

Treatment.—When the virgin brown silt loam was first cropped, the soil was in fine tilth, worked easily, and large crops could be grown with much less work than now. Continuous cropping, however, to corn or corn and oats with the burning of corn stalks, stubble, grass, and in many cases even straw, has destroyed the tilth in a great measure and now the soil is more difficult to work, washes badly, runs together, and bakes more readily. Unless the moisture conditions are very favorable, the ground plows up cloddy and unless well-distributed rains follow, a good seed bed is difficult to produce. The clods may remain all season. Much plant food is locked up in them and thus made unavailable, so that the best results cannot be obtained. This condition of poor tilth may become serious if the present methods of management continue; it is already one of the factors that limits crop yields. The remedy is to increase the organic-matter content by plowing under every available form of vegetable material, such as farm manure, corn stalks, straw, clover, stubble, and even weeds.

The deficiency of organic matter in the soils is shown by the way the fall-plowed land runs together during the winter. Much more work is required to produce a seed bed than was formerly the case. The result is that corn is frequently planted in poorly prepared seed beds and as a consequence it "fires" badly. Fall-plowed land should be disked early and deep for the purpose of conserving moisture, raising the temperature, and making plant food available.

The addition of fresh organic matter is not only of great value in improving the physical condition of this type of soil, but it is of even greater importance because of its nitrogen content and because of its power, as it decays, to liberate potassium from the inexhaustible supply in the minerals of the soil, and phosphorus from the phosphate contained in or applied to the soil.

For permanent, profitable systems of farming on brown silt loam, phosphorus should be applied liberally; and sufficient organic matter should be provided to furnish the necessary amount of nitrogen. On much of the type, limestone is already becoming deficient. An application of 2 tons of limestone, where needed, and ½ ton of finely ground rock phosphate per acre every four years, with the return to the soil of all manure made from a rotation of corn, corn, oats, and clover, will maintain the fertility of this type, altho heavier applications of phosphate may well be made during the first two or three rotations, and the first application of limestone may well be 4 tons per acre. If grain farming is practiced, the rotation may be wheat, corn, oats, and clover, with an extra seeding of clover (preferably sweet clover) as a cover crop in the wheat, to be plowed under late in the fall or in the following spring for corn; and most of the crop residues, including the clover chaff from the seed crops, should also be plowed under. In live-stock farming, the regular rotation may be extended to five or six years by seeding both timothy and clover with the oats, and pasturing one or two years. Alsike may well replace red clover at times, in order to avoid clover sickness. In either system, alfalfa may be grown on a fifth field and moved every five years, the hay being fed or sold. For results secured in field experiments on brown silt loam, see page 52 of the Supplement.

Brown Sandy Loam (260, 560, 760, 960, 1160)

Brown sandy loam occurs chiefly in the western part of the county. It covers 20.21 square miles, or 2.34 percent of the area of the county. In topography it is somewhat undulating, owing to the fact that sand was deposited over much of the area in the form of low dunes. The soil was later formed from this sand. In other areas, the undulating character of the surface is due to irregular deposition of the glacial drift, while in still others the irregularities are due to erosion. In these latter cases sand has been added to the soil thru the agency of wind. Small areas of brown sandy loam have been covered with forest, but not long enough to change the character of the soil to any extent.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam, varying in color from black to light brown or yellowish brown. In sand content it varies from 50 to 80 percent, but the larger part of the area is of the more sandy phase, with approximately 65 to 70 percent of sand. The organic-matter content of the surface stratum varies from 1.6 to 3.4 percent, with an average of 2.3 percent, or 23 tons per acre. The amount is less in the more sandy phase, which usually occupies the more rolling or dune-like parts.

The natural subsurface varies from 6 to 18 inches in thickness and is mostly yellowish brown, brownish yellow, and yellow in color. The subsurface is not separated from the subsoil by a distinct line, but passes into it gradually, as indicated by the gradual change in color, and usually by an increase in sand content. The stratum is deeper on well-drained areas where roots are able to penetrate to a considerable depth. The amount of organic matter in the stratum sampled (6⅔ to 20 inches) varies from 1.3 to 1.7 percent, averaging 1.5 percent, or 30 tons per acre.

The natural subsoil begins at a depth of 12 to 24 inches. It varies in physical composition from a sandy silt to a yellow medium sand. The stratum 20 to 40 inches contains about .6 percent of organic matter.

Treatment.—This type is generally well drained. A few small areas need artificial drainage.

In the management of brown sandy loam, the organic matter should be increased or at least maintained by turning under farm manure, crop residues, and legumes. Organic matter, in addition to furnishing nitrogen, will prevent the movement of sand by the wind, which is very likely to take place on the more sandy areas as the organic content is diminished. On the very sandy areas, cowpeas or sweet clover are good legumes to grow. Ground limestone and organic manures are of the greatest importance in the improvement of this soil. While the total supply of phosphorus is much less than in the brown silt loam, the porous character of the subsurface and subsoil, which affords a deep feeding range for plant roots, is likely to more than counterbalance this lack, so that the application of phosphorus is not advised except where other limiting soil factors have been provided for. Initial applications of 3 to 4 tons per acre of limestone should be made with about 2 tons every four or five years thereafter.

Black Clay Loam (520, 920, 1120)

Black clay loam is one of the types that represent the flat, heavy, prairie land that is sometimes called "gumbo," because of its sticky character. Its formation in the flat, poorly drained areas is due to the accumulation of organic matter and the washing in of clay and fine silt from the slightly higher adjoining lands. This type occupies 979 acres, or .18 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a black, granular, plastic clay loam varying to black clayey silt loam. It contains about 7.4 percent of organic matter, or 74 tons per acre.

The natural subsurface stratum has a thickness of 10 to 16 inches, and varies from a black at the top to a pale yellowish drab clay loam, usually somewhat heavier than the surface soil. The stratum as sampled (6⅔ to 20 inches) contains about 3.4 percent of organic matter, or 68 tons per acre. The stratum is pervious to water, owing principally to the jointing or checking from shrinkage in times of drouth.

The subsoil to a depth of 40 inches varies from a drab to a yellowish drab silty clay. As a rule, the iron is not highly oxidized, because of poor drainage and lack of aeration. Concretions of carbonate of lime are sometimes found. The perviousness of the subsoil is about the same as that of the subsurface, and is due to the same cause. When thrown out on the surface where wetting and drying may take place, it soon breaks into small cubical masses.

Black clay loam grades into other types, especially into black silt loam and brown silt loam. The washing in of silty material from the higher surrounding land, especially near the edges of the area, gives the surface a silty character. This change is taking place more rapidly now than formerly, when washing was largely prevented by prairie grasses.

Treatment.—Drainage is the first requirement in the management of this type. It is easily tile drained where an outlet is obtainable. Keeping the soil in good tilth is very essential, and thoro drainage helps to do this to a great extent.

As the organic matter is destroyed by cultivation and nitrification, and as the limestone is removed by cropping and leaching, the physical condition of

the soil becomes poorer, and as a consequence it becomes more difficult to work. Both organic matter and limestone develop granulation, a very necessary condition for maintaining the tilth, especially of heavy soils. The organic matter should be maintained by turning under farm manure and crop residues, such as corn stalks and straw, and by the use of clovers and pasture in rotations.

Altho the sample collected in Bureau county shows no limestone present, this type is likely to vary in this respect. It is therefore advisable to apply the simple tests for limestone described in the Appendix (page 43), and in case limestone is not present this material should be applied at the rate of at least 2 tons per acre.

While black clay loam is one of the best soils in the state, yet the clay and humus which it contains give it the property of shrinkage and expansion to such a degree as to be somewhat objectionable at times, especially during drouth. When the soil is wet, these constituents expand, and when the moisture evaporates or is used by the crops, they shrink. This results in the formation of cracks which are sometimes as much as two or more inches in width at the surface and extend with lessening width to two or three feet in depth. These cracks allow the soil strata to dry out rapidly, and as a result the crop is injured thru lack of moisture. They may do considerable damage by "blocking out" hills of corn and severing the roots. While cracking may not be prevented entirely, good tilth and a soil mulch will do much toward that end. Both for aeration and as a means of producing a mulch for conserving moisture, cultivation is more essential on this type than on the lighter types of soil. It must be remembered, however, that cultivation should be as shallow as possible in order to avoid injuring the roots of the corn.

The results of field experiments on this type of soil are given on page 64 of the Supplement.

Black Silt Loam (225, 525, 725, 925, 1125)

Black silt loam occupies low, flat areas or sloughs, occurring in situations somewhat similar to those of the black clay loam (—20), but it has had more of the coarser material washed in, and as a result is somewhat friable and silty. It covers a total area of 4,813 acres. In topography, this type is flat and naturally poorly drained.

The surface soil, 0 to 6⅔ inches, is a black silt loam varying on the one hand to brown silt loam, and on the other to black clay loam, and even grading toward muck in some cases. It is quite granular, and as a result is very pervious to both air and water. It contains 10.1 percent of organic matter, or 101 tons per acre. This is one of the richest soils in organic matter excepting the peats.

The natural subsurface is from 12 to 16 inches thick, and is a black to a dark brown clayey silt loam becoming drab or yellowish drab at the beginning of the subsoil. The subsurface stratum (6⅔ to 20 inches) contains 4.9 percent of organic matter, or 98 tons per acre.

The subsoil is a yellow or drabbish yellow clayey silt that permits free movement of water.

Treatment.—In the management of this type the same precautions should be observed with respect to drainage and the maintenance of organic matter as in the management of black clay loam.

Brown-Gray Silt Loam on Tight Clay (228, 528, 1128)

Brown-gray silt loam on tight clay is found only in small isolated areas that cover altogether but 83 acres. These areas usually occupy depressions in which some peculiar conditions of drainage have produced this soil.

The surface soil, 0 to 6⅔ inches, is a brown silt loam with areas of a grayish tint, especially when the soil becomes dry following a rain. The surface stratum contains about 4.1 percent of organic matter, or 41 tons per acre.

The subsurface is a gray silt loam becoming more yellow as the subsoil is approached. It is slowly pervious to water. This stratum contains 1.7 percent of organic matter. A sudden decrease in the organic matter content of the subsurface is characteristic of this type.

The subsoil is a tough, plastic, impervious clay, of a brownish gray or yellow color.

Treatment.—The first requirement of this type is good drainage, and this is somewhat difficult to secure at first because of the impervious character of the soil. After the soil is thoroly tile-drained, from 3 to 5 tons per acre of crushed limestone should be applied, and deep rooting crops, such as red, mammoth, or preferably sweet clover, should be grown. These legumes, along with any available manure and crop residues, should be turned under for soil improvement. Applications of from ½ to 1 ton per acre of rock phosphate should be made every four or five years until 2 tons have been applied.

Dune Sand (581, 781, 981, 1181)

The dune sand on the upland occurs as small, irregular patches scattered over the sandy-loam areas and widely distributed over the west half of the county. They represent the higher dunes of this county, which have never been covered with finer material or from which the fine material has been removed by wind and water. The total area is 160 acres, or .02 percent of the area of the county. This dune sand type does not differ from the terrace dune sand, and for further discussion of its character and treatment the reader is referred to the description of terrace dune sand (page 25).

Gravelly Loam (290, 790, 990, 1190)

Gravelly loam occurs principally in Towns 15 and 16 North, Range 7 East, in small irregular areas, and covers altogether 1,005 acres in this county.

The surface soil, 0 to 6⅔ inches, is a brown gravelly loam containing 2.2 percent of organic matter, or 22 tons per acre.

The subsurface is a light brown gravelly sandy loam, having an organic-matter content of 1.1 percent.

The subsoil is a yellowish or brownish gravel.

Treatment.—Where this type does not contain too much coarse material, good crops may be grown. It is necessary that the organic matter be maintained or even increased.

(b) UPLAND TIMBER SOILS

The upland timber soils occur as irregular zones along streams and on or near somewhat steep morainal ridges. They are characterized by a yellow, yel-

lowish gray, or gray color, which is due to their facilities for oxidation and to their low organic-matter content. The deficiency of organic matter has been caused by the long-continued growth of forest trees. After the forest invaded the prairies two effects were produced: first, the shade from the trees prevented the growth of prairie grasses, the roots of which are mainly responsible for the large organic-matter content in prairie soils; second, the trees themselves added very little organic matter to the soil, for the leaves and branches either decayed completely or were burned by forest fires. Furthermore, the organic matter that had been produced by the prairie grasses became gradually dissipated during the occupation of the land by the trees. As a result, the organic-matter content of the upland timber soils has been reduced until it is decidedly lower than that of the adjacent prairie land. Several generations of trees were necessary to produce the present condition of the soil.

The upland timber soils comprize 135.46 square miles, or 15.67 percent of the entire area of the county.

Yellow-Gray Silt Loam (234, 534, 734, 934, 1134)

Yellow-gray silt loam generally occurs in the outer timber belts along streams. The type covers 78.37 square miles, or about 9 percent of the entire area of the county. In topography it is sufficiently rolling for fair surface drainage without much tendency to wash if proper care is taken.

The surface soil, 0 to 6⅔ inches, is a yellow, yellowish gray, gray, or grayish brown, silt loam, pulverulent, but not granular. The more nearly level areas are gray in color, while the more rolling phase of the type is a grayish yellow or brownish yellow. As the type approaches the brown silt loam it becomes decidedly darker. The organic-matter content varies from 2 to 3.5 percent, with an average of 2.6 percent, or 26 tons per acre. The greatest variation in the organic-matter content is found in the more rolling areas where erosion has taken place.

In some places it is extremely difficult to draw the line between the long-cultivated and somewhat eroded brown silt loam, and the yellow-gray silt loam. This is especially true in some parts of the upper Illinoisan glaciation, notably in Town 14 North, Range 8 East, and Towns 15 North, Ranges 6 and 7 East. Here the brown silt loam is quite rolling and the slopes have in some cases eroded sufficiently so that they are mapped as yellow-gray silt loam. They probably never have been timbered.

The variation in texture of the surface stratum is due, to some extent, to the irregular deposition of sand by the wind. In some of the yellow-gray silt loam areas near the former extensive swamp, sand has been blown onto the uplands, thus increasing the normal amount of sand to such an extent that some very small areas, not sufficiently large to map, are sandy loams.

The natural subsurface stratum varies from 3 to 5 inches in thickness on the more rolling parts and from 8 to 14 inches on the more level areas, with an average of about 10 inches. It is usually a gray, grayish yellow, or yellow silt loam. The organic-matter content of the stratum sampled (6⅔ to 20 inches) varies from .6 to 1 percent, with an average of .8 percent, or 16 tons per acre. The physical composition of the subsurface varies with the surface.

The subsoil is a yellow or a mottled grayish yellow clayey silt or silty clay, somewhat plastic when wet, but friable when only moist. It is pervious to

water. The subsoil varies in physical composition even more than the surface stratum. Frequently boulder clay constitutes part or all of the subsoil. Sometimes sand may be encountered in the subsoil at a depth of from 30 to 40 inches. The sand was deposited by the wind previous to the deposition of the loess which constitutes most of the soil material of the upland in Bureau county.

This type drains well except on some of the more level and older forested areas, where a somewhat tough and tight clayey layer has developed that retards the movement of water.

Treatment.—In the management of yellow-gray silt loam, it is very necessary to maintain or even to increase the organic-matter content. This is necessary in order to supply nitrogen and liberate mineral plant foods; to give the soil better tilth; to prevent running together during heavy rains; and to prevent erosion on the more rolling phase. Rotations should be practiced that for a time at least will keep the soil in pasture, clover, or alfalfa, and reduce the tilled crops to a minimum acreage.

The samples analyzed showed considerable acidity especially in the subsurface. In such cases ground limestone should be applied in order that legumes may be grown successfully. An initial application of 2 to 4 tons per acre is suggested, after which 1 to 2 tons per acre every four or five years will probably be sufficient. Since the soil is poor in phosphorus, this element should be applied. In permanent systems of farming, finely ground natural rock phosphate will be found the most economical form in which to supply the phosphorus, altho when prices are normal steamed bone meal or acid phosphate may well be used temporarily until plenty of decaying organic matter can be provided.

For results from practical field experiments upon yellow-gray silt loam, see page 65 of the Supplement.

Yellow Silt Loam (235, 535, 735, 935, 1135)

Yellow silt loam occurs as hilly and badly eroded land on the inner timber belts adjacent to the streams, usually in narrow irregular strips with arms extending up the small valleys. The type covers an area of 56.88 square miles, or 6.58 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a yellow or grayish yellow friable silt loam. It varies greatly in color, owing to recent erosion. In places the natural subsoil may be exposed, and this gives it a decidedly yellow color. When freshly plowed the soil appears yellow or grayish yellow, but when it becomes dry after a rain it is decidedly gray. The surface soil in some places may be composed of boulder clay, which usually contains more or less gravel. The area of this, however, is very limited. Near sandy-loam areas the surface soil may be somewhat sandy and may even become a sandy loam, but these areas are usually too small to be shown on the map. The organic-matter content varies from 2 to 2.4 percent, with an average of 2.2 percent, or 22 tons per acre.

The natural subsurface varies from an inch or two to 12 inches in thickness, and is usually a yellow silt loam, altho on the steepest slopes it may consist of a clayey silt loam. In other places it may contain a considerable amount of sand. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 14 tons per acre.

The subsoil is normally a yellow clayey silt. On the more eroded areas, however, it may be composed in part or entirely of boulder clay or drift, and

where the wind has transported a great deal of sand the subsoil may be sandy or even a sand.

Treatment.—The first and most important point in the management of this type is the prevention of general surface-washing and gullying. If the land is cropped at all a rotation should be practiced that will require cultivated crops as little as possible and allow pasture and meadow most of the time. If tilled, the land should be plowed deeply and contours should be followed as nearly as possible in plowing, planting, and cultivating. Furrows should not be made up and down the slopes. Every means should be employed to maintain and to increase the organic-matter content. This will help to hold the soil and keep it in good physical condition so that it will absorb a large amount of water and thus diminish the run-off. (See Bulletin 207, "Washing of Soils and Methods of Prevention.")

According to the analyses of the samples of yellow silt loam collected in Bureau county, limestone is sometimes present in the subsoil but none of this material is contained in the surface or subsurface. However, it is known that in this general region of the state limestone occasionally occurs in abundance in the subsurface stratum. In view of this fact, therefore, it is recommended that the test for soil acidity, as described in the Appendix, be made. If this test indicates the absence of limestone near the surface, then this material should be applied at the rate of 2 to 4 tons per acre.

One of the best crops to be grown on land that is gullied or is likely to wash badly is sweet clover. This furnishes a large amount of good pasture and encourages the growth of blue-grass. Both the clover and the blue-grass tend to hold the soil and prevent washing. Alfalfa is another good legume crop to be grown on this type of soil. It will be useless, however, to sow either sweet clover or alfalfa if the soil is acid.

For an account of experiments with yellow silt loam soil the reader is referred to page 67 of the Supplement.

Yellow-Gray Sandy Loam (964, 1164)

The total area of yellow-gray sandy loam amounts to but 134 acres. It occurs along Bureau creek where the sand has been blown onto the upland.

The surface soil, 0 to 6⅔ inches, contains 1.6 percent of organic matter, or 16 tons per acre, and consists of a yellow or a grayish yellow sandy loam.

The subsurface contains .6 percent of organic matter, or 12 tons per acre. It is more sandy than the surface and passes into a yellow sand.

The subsoil is a yellow sand.

Treatment.—The primary consideration in the management of this type is the increasing of the organic-matter content. This may be done by turning under farm manure, crop residues, and legume crops. From 3 to 4 tons per acre of limestone may well be applied for the successful growing of clovers.

(c) TERRACE SOILS

Terrace soils have been developed on terraces or old fills in valleys. A large area in the northwestern part of Bureau county was formerly rather low and swampy. This is a broad terrace formed by deposits made by the Rock and

Green rivers during the period when the early and the late Wisconsin glaciers were melting. Large amounts of sand and gravel were carried down the flooded Rock river and were spread out over an extensive area in this part of the state forming a region known as the Winnebago swamp. This deposit is more than 200 feet deep. It is very probable that the old valley that connected the Rock river with the Illinois aided in producing the extreme width of the terrace in this region. Much of the sand that was deposited by streams was re-worked by the wind, producing the sand dunes of the county. Distinct terraces are found along Bureau creek and some of its tributaries as well as along the Illinois river. These were formed in the usual way by the partial filling up of the valley by overloaded streams which later cut down thru this fill, leaving the terrace from 20 to 50 feet above the present flood plain of the stream.

Brown Silt Loam over Gravel (1527)

Brown silt loam over gravel covers 59.65 square miles, or nearly 7 percent of the area of the county. A few small areas occur along Bureau creek and its tributaries, but most of the type is to be found in the terrace region in the west half of the county. The topography varies from flat to slightly undulating.

The surface soil, 0 to 6⅔ inches, is a brown to a dark brown granular silt loam containing from 3.3 to 7.8 percent of organic matter, with an average of 5 percent, or 50 tons per acre. In this constituent it differs but little from the brown silt loam of the upland. In physical composition the soil varies from a dark brown clayey silt loam to a silt loam with a considerable percentage of sand. Occasionally very small areas of sandy loam occur which are not large enough to be shown on the map.

The natural subsurface stratum varies from 8 to 12 inches in thickness and is a brown to a yellowish brown silt loam, containing in many cases a perceptible amount of sand.

The subsoil usually consists of a pale yellow to a drabbish or grayish yellow, slightly clayey silt, but it varies considerably. In some places the subsoil is rather sandy and may even pass thru gray-colored sand, and in others some gravel is found mixed with the finer clayey material.

Treatment.—Much of the type has been artificially drained. The strata are pervious and afford ready movement of water. Gravel or sand is not usually encountered until a depth of 55 to 60 inches has been reached. This deposit would afford good underdrainage if the water table could be lowered sufficiently.

In the management of this type, organic matter must be maintained by every available means, especially on the undulating phase. The phosphorus content is slightly lower than that of the upland brown silt loam. With respect to phosphorus the same treatment is recommended as that given for the upland brown silt loam, page 14. Applications of from 2 to 3 tons per acre of limestone will in all probability be profitable for the growing of clovers.

Brown Sandy Loam (1560)

Brown sandy loam covers an area of 27.94 square miles, or 3.24 percent of the area of the county. It is confined mostly to the northwestern part of the terrace or swamp area. In topography, it varies from flat to somewhat rolling.

the rolling character being produced by sand dunes. In the sand dune areas it usually occupies the lower lying parts.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam containing about 3.1 percent, or 31 tons per acre of organic matter. It varies in texture from a somewhat fine to a coarse sand.

The natural subsurface is about 14 inches in thickness and consists of a brown to a brownish yellow sandy loam, rather variable in sand content. The organic-matter content is 1.7 percent, or 34 tons per acre, in a stratum 13⅓ inches thick.

The subsoil varies from a yellow silty sand to a yellow sand.

Treatment.—All strata are pervious to water so that underdrainage takes place readily. Natural drainage is not always sufficient and therefore it is sometimes advisable to resort to artificial drainage.

After drainage, the maintenance of organic matter and nitrogen are the most important considerations in the management of this type. These materials may be provided by utilizing the farm manure produced and supplementing this by turning under corn stalks, straw, and clovers when these are not fed on the farm. Altho the content of phosphorus is not high, fair results may be obtained without the application of phosphorus because of the large feeding range of the plant roots in this loose soil. In time, however, as the content is reduced, applications of this element will doubtless be profitable. Since all strata of this type of soil are lacking in limestone, an initial application of 3 to 4 tons per acre of this material should be made, with 1 to 2 tons every four or five years thereafter.

Black Sandy Loam (1561)

Black sandy loam is found entirely in the terrace area in the northwest part of the county. It is most abundant in the vicinity of Green river, an area which was at one time occupied by an old lake or swamp. The topography is flat with only very slight undulations, rarely more than a foot or two in height. The total area covered amounts to 8,627 acres.

The surface soil, 0 to 6⅔ inches, is a black sandy loam, usually containing sufficient clay to render the soil slightly plastic. This stratum contains in the main about 6.4 percent of organic matter, or 64 tons per acre, altho the organic-matter content varies rather widely, and small local areas contain a sufficient amount to be classed as peaty loam. Soils of this kind do not usually possess plasticity.

The natural subsurface soil, which is from 14 to 16 inches in thickness, varies from black to brown in color, and passes into a yellowish sandy material in the subsoil. In some places a perceptible amount of gravel occurs. The stratum sampled (6⅔ to 20 inches) contains 2.2 percent of organic matter, or 44 tons per acre.

The subsoil varies from a yellow, drabbish yellow, or drab, clayey sand to a yellow or drab sand. It contains .9 percent of organic matter.

Treatment.—The type generally needs drainage. Drainage and good cultivation are the principal points in its management. Spots of alkali are frequently found on which corn does not do well, and where oats lodge badly. Applications of coarse stable manure, potassium salts, or a crop of sweet clover turned

under will enable a good crop of corn to be grown. Sweet clover does especially well on soil of this character. The black sandy loam is becoming slightly acid in many places.

Dune Sand (1581)

Dune sand of the terrace occupies 6,906 acres, or 1.25 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a light brown or grayish yellow loamy sand containing about 1.1 percent of organic matter, or 11 tons per acre.

The subsurface varies from a light brownish yellow to a yellow sand. It contains .7 percent of organic matter.

The subsoil is yellow sand.

Treatment.—In the management of this type, the principal problems are to prevent blowing and to maintain the supply of nitrogen. In this county there would be very little blowing of these sandy areas if they were left in their natural state. In many places the native vegetation has been destroyed by pasturing too closely or by cropping, thus giving the wind an opportunity to do its work. This results in the formation of "blow-outs," which are simply small areas, from a fraction of an acre to five acres in size, from which the sand is being blown. The sand from these blow-outs usually covers some better soil in the vicinity. The action of the wind may result in the ruin of the land if some protection is not given it. Wind erosion on this soil is worse than water erosion on other soils. Sand possesses very little cohesion, and it therefore is readily moved by the wind; but when organic matter is added this acts as a feeble cement that is sufficiently strong, however, to bind the particles together and thus prevent blowing.

To prevent the movement of sand by the wind, it is necessary either to have wind breaks, or to keep the soil covered with vegetation, or to incorporate organic matter. The latter two methods are really the only practical ways of preventing blowing. Every means should be used for increasing the organic matter content and for keeping a cover crop on the soil during the larger part of the year. Small grains are better adapted to accomplish this than corn.

The plants that are best adapted to sand dunes are legumes, which to a very large extent are independent of the nitrogen in the soil. It is interesting to know that a few legumes have adapted themselves to the sand to a remarkable degree. The climbing wild bean is a legume that is growing very abundantly on sand areas. It reseeds itself without any difficulty, and wheat or rye fields are soon covered with a growth of this plant after the crop has been removed. In some cases a ton or more to the acre is produced. It would seem that this plant might well be distributed over all the sand areas, especially those that are likely to blow.

Cowpeas are well adapted to growing on these sand soils. They furnish a large amount of organic matter to hold the sand and also the necessary nitrogen for growing other crops. Where wheat or rye is grown, the drill, with peas, should follow the binder. Normally they will make sufficient growth to add a considerable supply of organic matter and protect the soil during the winter. If the land is reseeded to wheat, the cowpeas may well be allowed to stand and

the wheat seeded in them, leaving the vines to protect the sand during the winter. Recent experiments show that two of the best crops for sand are sweet clover and alfalfa.

FIG. 1.—A LARGE "BLOW-OUT" WITH MANY SMALLER ONES IN THE DISTANCE
A SAND FARM MAY SOON BE RUINED BY NEGLECT

In the growing of a corn crop on sandy land, the lower blades usually die prematurely. This is commonly spoken of by farmers as "firing" and is attributed to a lack of moisture. While a deficiency of moisture may be responsible to a certain extent, the trouble is more often due to a lack of the element nitrogen. A liberal supply of organic matter, especially that from legumes, will do much to prevent firing.

In the management of a crop on sandy land, cultivation should be practiced no more than is absolutely necessary and should then be as shallow as possible. Sand is naturally well adapted to prevent moisture from evaporating, and there is no necessity for any more cultivation than is really necessary to kill the weeds. Some farmers in Michigan never cultivate their corn crop on sand soil, but instead cut out what few weeds there are with a hoe, and they succeed in raising larger crops than where cultivation is practiced.

Foresting is a practical way of conserving these sand soils. Black locust (a leguminous tree) seems to do exceptionally well on sand. One difficulty that has been experienced is that the locust tree is damaged by borers; but if it is used to start a growth and hold the sand temporarily, other trees may then be interplanted with the result that the sand will be held permanently. After the blowing of sand is once stopped, very careful treatment is required to prevent a recurrence of the trouble. Pasturing should be done very carefully, so that the grass will not be entirely destroyed.

While the acidity is not high, the sand soil is entirely devoid of limestone. For satisfactory results, therefore, an application of from 2 to 4 tons per acre of limestone is recommended, and the supply should be maintained by subsequent applications every four or five years. When potash salts can be secured

at reasonable cost, their use is likely to produce profitable results, at least temporarily, in getting under way systems of permanent improvement. This applies more especially to the level areas, which were originally sandy swamps.

As the nitrogen content is exceedingly low, successful crop production on this type of soil rests upon the building up of the supply of this element, and this can be accomplished thru the growth of legumes as recommended above.

The phosphorus content of this sand type is not high, only 780 pounds per acre of this element being present in the plowed soil, but it exists to a considerable extent in other constituents than sand grains. This is shown by some work of the United States Bureau of Soils in which two types of sandy soil, glacial sand and sandy loam, were separated into coarse and fine particles. Each grade was analyzed for phosphorus, and it was found that as an average of the two soils the fine portion was eighteen times as rich in the element phosphorus as the coarse. Under successful cropping, the limited amount of phosphorus contained in this dune sand would sooner or later become exhausted, altho field experiments might not indicate a need of phosphorus at first.

FIG. 2.—THE TRAILING WILD BEAN HOLDS THE SAND AND ADDS NITROGEN AND ORGANIC MATTER

The total supply of potassium is much smaller than is found in the more common soils. As to its availability for growing crops on sandy soils, field experiments have shown some discrepancies in results, owing probably to a variation in the condition in which the potassium exists. Definite recommendations, therefore, regarding the application of potassium to this type of soil must await the collection of more reliable information. (On swamp sands and sandy loams long exposed to leaching, potassium is often the first limiting element, especially where a fair supply of humus exists, as in the so-called "black sand.")

For an account of field experiments on sand soil see page 70 of the Supplement.

Black Mixed Loam (1550)

Black mixed loam occurs in the terrace region in the northwest part of the county, principally in Town 18 North, Range 7 East. The total area covered amounts to 2,515 acres. The topography is flat with occasional slight undulations not more than two feet in height.

The surface soil, 0 to 6⅔ inches, is a black loam, so variable in composition that it cannot be divided into distinct soil types. Small areas may be peat, others peaty loam, black clay loam, or sandy loam, and this mixed character makes it impossible to separate it into distinct types. The surface stratum contains about 10.5 percent of organic matter, or 105 tons per acre.

The natural subsurface usually varies from 14 to 18 inches in thickness, and is a black mixed loam becoming drab or drabbish yellow with depth. The organic-matter content is approximately 3.9 percent, or 78 tons per acre in a stratum twice the thickness of the surface soil.

The subsoil is variable in composition and color, but usually consists of a mixture of clay, silt, sand, and gravel. It contains about 1.2 percent of organic matter.

Treatment.—This soil is very rich in organic matter, nitrogen, and phosphorus. The first thing to be considered in the management of this type is drainage, and the pervious character of the strata enables this to be accomplished very readily where the proper outlet can be obtained. This type contains many alkali areas, the treatment of which should be the same as that recommended for the alkali spots in the black sandy loam (1561) described above.

Black Silt Loam (1525)

Black silt loam is found in the terrace area of the western part of the county, and occupies the low, undrained areas of the higher part of the terrace. The total area amounts to 3,149 acres. The topography is flat with an occasional slight undulation of a foot or two. These higher parts are frequently strongly alkaline, and require special treatment before corn and oats can be grown successfully.

The surface soil, 0 to 6⅔ inches, is a black silt loam, which varies from a clayey silt, bordering on black clay loam, to a slightly sandy phase. Occasional patches which are very high in organic matter cause the type to grade toward clayey muck. This stratum contains about 6.1 percent of organic matter, or 61 tons per acre.

The natural subsurface, which is represented by a stratum 12 to 20 inches thick, is a black silt loam varying on one hand to a black clay loam, and on the other to sandy loam. The subsurface stratum as sampled (6⅔ to 20 inches) contains about 5.9 percent of organic matter, or 118 tons per acre.

The subsoil is a blackish to drabbish yellow clayey silt or silty clay, frequently containing some pebbles and a considerable amount of sand in local areas. It contains about 2.1 percent of organic matter. In one area a bright, brownish yellow stratum about 2 or 3 inches in thickness was found in the subsoil. This material contained so much phosphorus as to cause the subsoil sample, 20 to 40 inches, to show over 33,000 pounds per acre.

Treatment.—The first requirement of this soil is drainage, and this, with good cultivation, is about all that is needed for the present.

Yellow-Gray Sandy Loam (1564)

Yellow-gray sandy loam occurs in the terrace in the northwest part of the county and covers 3,174 acres. It represents some of the higher areas, together with many sand dunes, that have been covered with finer material. The character of the soil has been somewhat modified by the growth of forests consisting principally of black oak (*Quercus marylandica*). The topography varies from flat to somewhat rolling, the latter condition being caused by sand dunes.

The surface soil, 0 to 6⅔ inches, is a yellow to grayish yellow and brownish yellow sandy loam, usually containing large amounts of sand and grading into dune sand in many places. On this type, many small areas, especially those having dune topography, could be mapped as sand, were the areas large enough. The surface stratum contains about 2.4 percent of organic matter, or 24 tons per acre.

The subsurface varies from a silty sand or even a sandy silt to pure sand, and is usually yellow in color. There is a decrease in the amount of organic matter in the subsurface, the analysis of which shows only .7 percent.

The subsoil consists of a yellow silty sand or sand.

Treatment.—The type is rather low in productiveness, due to the low organic-matter content. The best way to improve this condition is to turn under manures and all crop residues possible. The addition of limestone to the amount of 3 or 4 tons per acre will permit the growing of clover, which is so effectively used for soil renovation. Sweet clover could be used to excellent advantage on this type. The entire crop with the exception of the seed should be turned under.

Brown Fine Sandy Loam (1571)

In the northeast township of the county, there are several areas of brown fine sandy loam that aggregate 1,165 acres. This type varies in topography from flat to slightly undulating.

The surface soil, 0 to 6⅔ inches, is a brown fine sandy loam, varying on one hand to a brown silt loam, and on the other hand to a brown medium sandy loam. It contains some small areas of ordinary sandy loam that represent low dunes. The organic-matter content is about 4.4 percent, or 44 tons per acre.

The natural subsurface is represented by a stratum 8 to 12 inches thick, and is a brown fine sandy loam, usually becoming more sandy with depth until it passes into a yellow silty sand. The subsurface stratum as sampled (6⅔ to 20 inches) contains about 1.9 percent of organic matter, or 38 tons per acre.

The subsoil is a yellow to a drabbish yellow silty sand, frequently passing into almost pure medium sand.

Treatment.—After drainage, the maintenance of organic matter and nitrogen is the principal consideration in the management of this type. Applications of 3 or 4 tons per acre of limestone should be made for the successful growing of clover.

Black Clay Loam (1520)

A few areas of black clay loam are found on the upper terrace that aggregate but 422 acres. The topography is flat.

The surface soil, 0 to 6⅔ inches, is a black, plastic, granular clay loam, varying toward a black silt loam. It contains about 7.5 percent of organic matter, or 75 tons per acre.

The natural subsurface, 10 to 18 inches in thickness, is a black to a dark drab clay loam, considerably heavier than the surface. The stratum as sampled (6⅔ to 20 inches) contains about 4.2 percent of organic matter, or 84 tons per acre.

The subsoil is a heavy drab to yellow clay loam, containing about 1.5 percent of organic matter. It contains in some cases a small amount of gravel.

Treatment.—Drainage is the first requirement of this type. In spite of the heavy character of the strata, drainage takes place readily, due to the joints in the soil produced by shrinkage in times of drouth.

In this type it is doubly necessary to maintain the supply of organic matter in order to keep the soil in good physical condition and to give it easy working qualities. Limestone also must be maintained for the same purpose.

Brown-Gray Sandy Loam on Tight Clay (1568)

Brown-gray sandy loam on tight clay is scattered over a considerable area of the terrace, but not in large tracts. The total area covered by the type is 1,562 acres, or .28 percent of the entire county. For some reason a large amount of very fine material has been deposited at variable depths in this type, which has resulted in producing a tight layer thru which water passes with great difficulty. This has changed the color of the subsurface soil to a gray, and has rendered the soil less valuable. The topography of this type is generally flat.

The surface soil, 0 to 6⅔ inches, is a brown to a grayish brown sandy loam. When freshly plowed, the grayish color becomes more evident shortly after a rain. Usually the gray shows up in small areas not more than three to six rods in diameter. This stratum contains about 2.8 percent of organic matter, or 28 tons per acre. In physical composition it varies somewhat toward a brown silt loam.

The natural subsurface is represented by a layer 8 to 12 inches thick which consists of a grayish sandy silt loam that varies to a gray sandy loam. The organic-matter content of the stratum 6⅔ to 20 inches is about 1.4 percent.

The subsoil is rather variable. The tight clay is not uniform in depth, but may occur at depths ranging from 16 to 30 inches. The thickness, too, is variable. The subsoil in general is a gray to yellowish gray sand with the tight stratum consisting of a sandy clay or a clayey sand.

Treatment.—Drainage is one of the first requirements of this type of soil. The presence of the tight clay stratum in the subsoil retards drainage to such an extent that the lines of tile must be placed not more than four or five rods apart, and even closer than this would be better. Deep-rooting crops are very desirable, especially sweet clover, but it must be remembered that inoculation and plenty of limestone are needed in growing it. The deep roots penetrate the tight clay layer and will in time render it more pervious. At the same time, organic matter must be added to the soil to increase granulation. As the limestone moves downward, it too has a beneficial effect on granulation and tends to make the soil more porous. Since the soil is acid, 4 or 5 tons per acre of limestone should be applied at first with about 2 tons every four years afterward.

Yellow-Gray Silt Loam over Gravel (1536)

Yellow-gray silt loam over gravel occurs principally along the streams in the eastern and southern parts of the county as terraces from 40 to 60 feet above the present bottom land. The total area amounts to 2,118 acres. The topography varies from flat to slightly undulating, in some cases with a rather steep incline to the present flood plain. The areas occur as remnants of the former fill along Bureau creek and its branches, and also along the Illinois river.

The surface soil, 0 to 6⅔ inches, varies from a grayish yellow to a yellow silt loam, containing about 1.6 percent of organic matter, or 16 tons per acre.

The subsurface is a yellow silt loam, with approximately .6 percent of organic matter.

The subsoil is a yellow silt to a clayey silt. The gravel stratum is from 38 to 60 inches beneath the surface.

Treatment.—The drainage is good, owing to the presence of the deep subsoil gravel. The organic-matter content is very low, and every means should be used for increasing it. Limestone should be applied to permit the growing of large crops of legumes for soil improvement. In addition to these, straw, corn stalks, and all manure possible should be turned back into the soil. Phosphorus should be applied as the type is somewhat deficient in this element.

Yellow-Gray Sandy Loam on Gravel (1564.4)

Yellow-gray sandy loam on gravel covers an area of 211 acres. It is almost entirely confined to the terraces along the Illinois river.

The surface soil, 0 to 6⅔ inches, contains about 1.7 percent of organic matter or 17 tons per acre.

The subsurface is a yellow silt loam, passing into sandy and gravelly silt, the gravel beginning at from 18 to 24 inches. The subsurface contains about .5 percent of organic matter.

The subsoil is a silty gravel.

Treatment.—This type of soil needs for its improvement all the organic matter that can be economically worked into it. Besides organic matter and nitrogen it is also in need of phosphorus and limestone. Since the gravel is so near the surface, the type is not a good one to resist drouth.

Brown Sandy Loam on Gravel (1560.4)

Brown sandy loam on gravel occurs along Bureau creek and covers an area of 77 acres.

The surface soil contains about 2 percent of organic matter, or 20 tons per acre. It is a light brown sandy loam, the sand being mostly coarse.

The subsurface contains approximately 1.2 percent of organic matter.

Treatment.—The gravel is but 16 to 24 inches beneath the surface, and this renders the type a poor one to resist drouth. Its treatment should be similar to that recommended for the preceding type.

Brown-Gray Silt Loam on Tight Clay (1528)

The area of brown-gray silt loam on tight clay is very small, amounting to but 109 acres. It does not differ in character from the upland type; therefore, for recommendations the reader is referred to the discussion of this type under upland soils. (See page 19).

Gravelly Loam (1590)

There are only 109 acres of gravelly loam in the terrace. This should receive the same treatment as the upland type bearing this name. (See page 19).

(d) SWAMP AND BOTTOM-LAND SOILS

The bottom land of the Illinoisan glaciation represents the older bottom lands, while the Iowan and early Wisconsin represent the newer ones. There is but little difference between the two.

Mixed Loam (1354, 1454)

The mixed loam is found along practically all the small streams of the county, forming flood plains varying from a few rods to a mile in width. It covers a total area of 39.81 square miles, or 4.61 percent of the area of the county. Mixed loam varies widely in physical composition, including small areas of sand, sandy loam, silt loam, and even clay loam. These are usually so badly mixed that a separation is not practical. During flood times, the character of the soil may be changed entirely.

The surface soil, 0 to 6⅔ inches, consists of a mixed loam containing from 3.6 to 6.1 percent of organic matter with an average of 4.9 percent, or 49 tons per acre. The surface soil varies widely, a distance of a rod often giving entirely different kinds of soil. Small areas of peat may occur.

The subsurface, to a depth of 20 inches, is a dark soil of varying texture, containing about 3.6 percent of organic matter.

The subsoil varies from a brown to a drab or yellowish clayey silt to sandy silt. It is sufficiently pervious for good drainage.

Treatment.—No applications of plant food are advised for this type of soil, since it annually receives deposits from overflow sufficient to maintain the fertility of the soil. It usually grows good crops unless damaged by overflow or by poor drainage.

Deep Peat (1401)

Deep peat occurs mainly in the terrace region of the northwest part of the county. The total area covered is 6,400 acres, or 1.16 percent of the area of the county. Some of these peat deposits are very deep. One in Section 11, Town 16 North, Range 7 East is said to be 65 feet deep, while the area in Sections 10 and 11, Town 17 North, Range 7 East, is from 30 to 40 feet deep.

The surface soil, 0 to 6⅔ inches, consists of a brown to black, fairly well-decomposed material containing from 31 to 56 percent of organic matter with an average of 43.7 percent, or about 220 tons per acre.

The subsurface soil consists of material that is usually less decomposed than that of the surface. The samples taken contained the same percent of organic matter as the surface.

The subsoil contains, as an average, about 31 percent of organic matter.

Treatment.—The first requirement of this type is drainage. The best form of drainage, especially at first, is the open ditch. Peat, because of its loose, uncompacted condition, does not furnish a very good bed for tile. This may be remedied, however, by putting a board in the bottom of the ditch and placing the tiles on that.

Characteristic of peat, this soil is extremely rich in nitrogen, is well supplied with phosphorus, but is very deficient in potassium, as compared with ordinary fertile soils. Where thoro drainage can be provided either by open ditches or by laying tiles deep enough to secure a solid bed for them, very marked improvement can be made in the productive power of deep peat by the liberal use of potassium, which is the only deficient element. Stable manure, as well as straw and other crop residues which contain a certain amount of potassium, can be used to supply this element, altho a more economical use of the manure is made when applied to soil that can utilize the nitrogen to better advantage than does peat. Experimental results, as obtained by the Experiment Station, as well as practical experience on the part of farmers, have demonstrated that kainit and the mineral potassium compounds such as the chlorid, sulfate, or carbonate of potassium, are used on this kind of land with great profit.

For an account of field experiments on deep peat the reader is referred to page 72 of the Supplement.

Medium Peat on Clay (1402)

Medium peat on clay occurs almost entirely within the terrace region and it covers an area of 2,061 acres. The topography is usually flat.

The surface soil, 0 to 6⅔ inches, is a brown to black peat, and contains about 44 percent of organic matter.

The subsurface is a sandy or clayey material containing about 20 percent of organic matter. The upper half of the subsurface is usually peaty, and the amount of organic matter gradually diminishes until at a depth of about 20 to 25 inches it passes into drab clay or clayey sand.

The subsoil varies largely in physical composition, but is usually a drab clay or a clayey sand.

Treatment.—The first requirement of this type is drainage. Owing to the peculiar make-up of this soil its method of management may be rather variable, particularly with respect to the application of potassium. The peaty layer of the surface is very deficient in potassium while at the same time there is a large store of this element in the clay lying at varying depths below the surface. Sometimes good crops are obtained at once after drainage has been effected. Sometimes but one application of potassium is required to start production. Sometimes the first crop is poor but subsequent crops become better owing to the accumulation of potassium near the surface brought up from below by the roots of the previous crops. Sometimes the gradual mixing of the materials of the upper and lower strata thru tillage produces a good effect. Now and then farmers report great success in improving this kind of land by deep plowing or subsoiling, whereby the clayey material becomes incorporated with the peaty substance.

Therefore, just what course to pursue in improving this land will depend to a large extent upon the depth of the peaty layer, and the farmer must be guided largely by experience. If, after thoro drainage has been effected, corn fails to grow well, the indication is that potassium is needed either to supply a natural deficiency or to overcome the effects of an alkaline condition that sometimes exists in this kind of soil.

Peaty Loam (1410)

Within the terrace region a large amount of peaty loam is found, the total area being 17.07 square miles, which is about 2 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, contains from 12 to 16 percent of organic matter. The mineral constituent is principally white sand.

The subsurface contains from 3.2 to 4.5 percent of organic matter, with an average of 3.8 percent.

The subsoil contains a little more than 2 percent of organic matter.

Treatment.—The first requirement of peaty loam is drainage. The types, peaty loam, (1410), black mixed loam (1450 and 1550), and black sandy loam (1461 and 1561) frequently have some areas which do not grow good crops, especially corn. The leaves of corn become striped with yellow, or turn yellow or brown. The growth is not large and the plant presents a leafy appearance due to the short joints of the stalk. These areas need potassium. It may be supplied by applying from 100 to 200 pounds per acre of potassium chlorid or potassium sulfate, or by turning under coarse manure, straw, or a green crop.

Much of the peaty loam contains spots of alkali, which are so strongly charged that grain crops will not grow. A crop of sweet clover turned under will be very beneficial on this alkali soil.

Black Clay Loam (1420)

Several small areas of black clay loam are found in the swamp region in Towns 16 and 17 North, Range 6 East. These cover a total area of 160 acres.

The surface soil, 0 to 6⅔ inches, is a black, plastic, very granular clay loam containing about 7.5 percent of organic matter, and grading in this respect toward clayey muck.

The subsurface is a black clay loam containing 4.2 percent of organic matter.

The subsoil is a dark drab clay loam containing 1.5 percent of organic matter.

Treatment.—Good drainage and good cultivation are the things necessary in the management of this type.

Black Silt Loam (1425)

Black silt loam is found in the low, swampy part in Towns 16 and 17 North, Range 6 East, occupying an area of 4,365 acres. The area is very flat and at one time was a lake or swamp.

The surface soil, 0 to 6⅔ inches, is variable in organic-matter content, but averages about 13 percent, or 130 tons per acre. In physical composition it varies from a black clayey silt to a black sandy loam with some small areas of peat or clayey muck.

The subsurface soil is a black clayey silt varying somewhat with the surface. It contains about 4.9 percent of organic matter.

The subsoil is drab to drabbish yellow in color. It contains 2.9 percent of organic matter.

Treatment.—The first requirement of this type is drainage, and after this is provided but little else is necessary other than good cultivation. Spots of alkali are found.

Deep Brown Silt Loam (1426)

Deep brown silt loam occurs only in the bottom land of the Illinois river. It covers 8,256 acres. It is flat and usually so wet and swampy that it cannot be cultivated.

The surface soil, 0 to 6⅔ inches varies from a clayey silt to a silt loam in texture, and from brown to black in color. It contains about 7.5 percent of organic matter.

The subsurface contains approximately 4.2 percent of organic matter. It becomes somewhat heavier with depth.

The subsoil varies to a greater extent than either of the other strata. In some cases peat or muck has been covered by deposits during floods, and these now form the subsoil. In one sample taken, the subsoil contained two times as much organic matter as the surface.

Treatment.—Where the land is workable good cultivation is about all that is necessary in the management of this type.

Black Mixed Loam (1450)

A number of small areas of black mixed loam occur in Town 17 North, Range 6 East, covering 422 acres.

This soil is very similar to the terrace type of the same name (1550), and should be managed in the same manner.

Black Sandy Loam (1461)

Black sandy loam is found as a broad swampy plain along the Green river and covers 5,606 acres, or about one percent of the area of the county. The area is very flat.

The surface soil is a black sandy loam containing some clay and varying from a sandy clayey silt to a sandy loam with 65 to 70 percent of sand. It contains about 9.9 percent of organic matter, or 99 tons per acre.

The subsurface soil contains 4.2 percent of organic matter, and varies somewhat the same as the surface.

The subsoil is drab in color and varies in physical composition from a sand to a clay loam, the most common being a sandy to a gravelly clay. The organic-matter content is about 1.6 percent. The subsoil frequently contains fragments of calcium carbonate.

Treatment.—Drainage and good cultivation are necessary for this type. Alkali spots are rather abundant. For treatment of alkali spots, see description of this type in the terrace (1561), page 24.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to intelligently interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification here used.

The unit in the soil survey is the soil type, and each type possesses more or less definite characteristics. The line of separation between adjoining types is usually distinct, altho sometimes one type grades into another so gradually that it is very difficult to draw the line between them. In such exceptional cases, some slight variation in the location of soil-type boundaries is unavoidable.

In establishing soil types several factors must be taken into account. These are: (1) the geological origin of the soil, whether residual, cumulose, glacial, eolial, alluvial, or colluvial; (2) the topography, or lay of the land; (3) the native vegetation, as forest or prairie grasses; (4) the depth and the character of the surface, the subsurface, and the subsoil, as to the percentages of gravel, sand, silt, clay, and organic matter which they contain, their porosity, granulation, friability, plasticity, color, etc.; (5) the natural drainage; (6) the agricultural value, based upon its natural productiveness; (7) the ultimate chemical composition and reaction.

Great Soil Areas in Illinois.—On the basis of the first of the above mentioned factors, namely, the geological origin, the state of Illinois has been divided into sixteen great soil areas with respect to their geological formation. The names of these areas are given in the following list along with their corresponding index numbers, the use of which is explained below. For the location of these geological areas, the reader is referred to the general map published in Bulletins 123 and 193.

100 *Unglaciated,* comprizing three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciation
300 *Lower Illinoisan glaciation,* covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river bottom and swamp lands,* found in the older or Illinoisan glaciation
1400 *Late river bottom and swamp lands,* those of the Wisconsin and Iowan glaciations
1500 *Terraces,* formed by overloaded streams draining from the glaciers and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago or the enlarged Lake Michigan

Mechanical Composition of Soils.—The mechanical composition, or the texture, is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents:

Organic matter: undecomposed and partially decayed vegetable material

Inorganic matter: clay, silt, fine sand, sand, gravel, stones.

Classes of Soils.—Based upon the relative proportion of the various constituents mentioned above, soils may be grouped into a number of well recognized classes. Following is a list of these classes, arranged according to their index numbers, the use of which is explained below.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

Naming and Numbering Soil Types.—The naming of soil types has been the subject of much discussion, and practice varies considerably in this matter. In this soil survey of Illinois a system of classification and naming has been adopted which is based upon the various considerations presented in the preceding paragraphs.

After texture, one of the most striking characteristics of a soil is the color. Therefore, in the naming of soils in Illinois, a combination of color and texture, together with other descriptive terms when necessary, has been adopted so that the name in itself carries a definite description of a given soil type; as for example, "gray silt loam on tight clay," or "brown silt loam over gravel." The use of the prepositions *on* and *over* serves to indicate the presence of certain substrata. When the surface soil is underlain with material such as sand, gravel, or rock, the word *over* is used if this material lies at a depth greater than 30 inches; if it is less than 30 inches, the word *on* is used.

For further identification of soil types a system of numbering, resembling somewhat the Dewey library system, has been adopted whereby each soil type is assigned a certain number. This number indicates at once the geological origin of the soil as well as its physical description. The digits of the order of hundreds represent the geological area where the soil is found, beginning at 100 with the unglaciated, and following in series in the order of the enumeration presented in the paragraph above headed *Great Soil Areas In Illinois.* The digits of the orders of units and tens represent the various kinds of soil such as are enumerated above in the list of soil classes. A modification of a soil type called a *phase* is designated in this system by a figure placed at the right of the decimal point. To illustrate the working of this numbering system, suppose a soil type bears the number 726.5. The number 7 indicates that this soil occurs in the Iowan glaciation, the 26 that it is a brown silt loam, and the .5 that rock is found less than 30 inches below the surface. These numbers are especially useful in designating small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and a description of the area covered, will be found in the respective county soil reports.

SOIL SURVEY METHODS

Mapping the Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. In order that the survey be thoroly truthworthy it is necessary that careful, well-trained men be employed to do the mapping. The work is prosecuted to the best advantage by working in parties of from two to four. Only such men are placed in charge of these parties as are thoroly experienced in the work and have shown themselves to be especially well qualified in training and ability.

The men must be able to keep their location exactly and to recognize the different soil types, with their principal variations and limits, and they must show these upon the maps correctly. A definite system is employed in checking up this work. As an illustration, one man will survey and map a strip 80 rods or 160 rods wide and any convenient length, while his associate will work independently on another strip adjoining this area, and if the work is correctly done the soil-type boundaries will match up on the line between the two strips.

An accurate base map for field use is absolutely necessary for soil mapping. The base maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as a basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil-type boundaries, together with the streams, roads, railroads, canals, and town sites are placed in their proper locations upon the map while the mapper is on the area. Each section, or square mile, is divided into 40-acre plots on the map, and the surveyor must inspect every ten acres and determine the type or types of soil composing it. The different types are indicated on the map by different colors, pencils for this purpose being carried in the field.

A small auger 40 inches long forms for each man an invaluable tool with which he can quickly secure samples of the different strata for inspection. An extension for making the auger 80 inches long is taken by each party, so that any peculiarity of the deeper subsoil layers may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by an odometer attached to the axle of the vehicle or by some other measuring device, while distances in the field away from the roads are determined by pacing, an art in which the men become expert by practice. The soil boundaries can thus be located with as high a degree of accuracy as can be indicated by pencil on the scale of one inch to the mile.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. For this purpose usually three strata are sampled; namely, the surface (0 to 6⅔ inches), the subsurface (6⅔ to 20 inches), and the subsoil (20 to 40 inches). These strata correspond approximately, in the common kinds of soil, to 2,000,000 pounds of dry soil per acre in the surface layer, and to two times and three times this quantity in the subsurface and the subsoil, respectively.

By this system of sampling we have represented separately three zones for plant feeding. The surface layer includes at least as much soil as is ordinarily turned with the plow. This is the part with which the farm manure, limestone, phosphate, or other fertilizer applied in soil improvement is incorporated, and which must be depended upon in large part to furnish the necessary plant food for the production of crops. Even a rich subsoil has little or no value if it lies beneath a worn-out surface, but if the fertility of the surface soil is maintained at a high point, then the strong, vigorous plants will have power to secure more plant food from the subsurface and subsoil.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. Even tho plowed alike and at the same time, prepared the same way, planted the same day with the same kind of seed, and cultivated alike, watered by the same rains and warmed by the same sun, nevertheless the best acre may produce twice as large a crop as the poorest acre on the same farm, if not, indeed, in the same field; and the fact should be repeated and emphasized that with the normal rainfall of Illinois the productive power of the land depends primarily upon the stock of plant food contained in the soil and upon the rate at which it is liberated, just as the success of the merchant depends primarily upon his stock of goods and the rapidity of sales. In both cases the stock of any commodity must be increased or renewed whenever the supply of such commodity becomes so depleted as to limit the success of the business, whether on the farm or in the store.

CROP REQUIREMENTS

Ten different elements of plant food are essential for the growth and formation of every plant. These elements are: *carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, magnesium, calcium, and iron;* and they are represented by the chemical symbols: C, O, H, N, P, S, K, Mg, Ca, and Fe. Some seasons in central Illinois are sufficiently favorable to allow the production of at least 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. When such crops are not produced under favorable seasonal conditions, the failure is due to unfavorable soil condition, which may

TABLE A.—PLANT FOOD IN WHEAT, CORN, OATS, AND CLOVER

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain......	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat, straw.....	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain.......	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover.......	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs........	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain.......	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw........	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed.......	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay.......	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00

result from poor drainage, poor physical condition, or an actual deficiency of plant food.

Table A shows the plant-food requirements of some of our most common field crops with respect to the seven elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of any element removed from an acre of land by a crop of a given yield can easily be computed.

It needs no argument to show that the continuous removal of such quantities of plant food without provision for their replacement must result sooner or later in soil depletion.

PLANT-FOOD SUPPLY

Of the ten elements of plant food, three *(carbon, oxygen,* and *hydrogen)* are secured from air and water, and seven from the soil. *Nitrogen,* one of these seven elements obtained from the soil by all plants, may also be secured from the air by one class of plants (legumes), in case the amount liberated from the soil is insufficient; but even these plants (which include only the clovers, peas, beans, and vetches among our common agricultural plants) are dependent upon the soil for the other six elements *(phosphorus, potassium, magnesium, calcium, iron, and sulfur)*, and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

TABLE B.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	19
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[1]	80	8	28
Dried blood	280	...	...
Sodium nitrate	310	...	...
Ammonium sulfate	400	...	...
Raw bone meal	80	180	...
Steamed bone meal	20	250	...
Raw rock phosphate	...	250	...
Acid phosphate	...	125	...
Potassium chlorid	...	...	850
Potassium sulfate	...	...	850
Kainit	...	...	200
Wood ashes[2]	...	10	100

[1]Young second year's growth ready to plow under as green manure.
[2]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

The vast difference with respect to the supply of these essential plant food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to nearly 33,000 pounds. In like manner the phosphorus content varies from about 420 pounds to 4,900 pounds, the potassium ranges from 1,530 pounds to about 58,000 pounds. Similar variations are found in all of the other essential plant food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table B is presented for the purpose of furnishing information regarding the quantity of plant food contained in some of the materials most commonly used as sources of plant-food supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of fertility actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are limestone and decaying organic matter. Tillage also has a considerable effect in this connection.

Effect of Limestone.—Limestone corrects the acidity of the soil and thus encourages the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the insoluble and unavailable organic nitrogen into soluble and available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium, and also to dissolve the insoluble phosphate and limestone which may be applied in low-priced forms. Thus, in the conversion of sufficient organic nirogen into nitrate nitrogen for a 100-bushel crop of corn, the nitrous acid formed is alone sufficient to convert seven times as much insoluble tricalcium phosphate into soluble monocalcium phosphate as would be required to supply the phosphorus for the same crop.

Effect of Organic Matter.—Organic matter may be supplied by animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter, and by plant manures, including green-manure crops and cover crops plowed under and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant food than the 20 tons of old, inactive organic matter. The history of the individual

farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated more or less definitely by the *ratio of carbon to nitrogen.* As an average, the fresh organic matter incorporated with soils contains about twenty times as much carbon as nitrogen, but the carbohydrates ferment and decompose much more rapidly than the nitrogenous matter; and the old resistant organic residues, such as are found in normal subsoils, commonly contain only five or six times as much carbon as nitrogen. Soils of normal physical composition, such as loam, clay loam, silt loam, and fine sandy loam, when in good productive condition, contain about twelve to fourteen times as much carbon as nitrogen in the surface soil; while in old, worn soils that are greatly in need of fresh, active, organic manures, the ratio is narrower, sometimes falling below ten of carbon to one or nitrogen. Except in newly made alluvial soils, the ratio is usually narrower in the subsurface and subsoil than in the surface stratum. Soils of cut-over or burnt-over timber lands sometimes contain so much partially decayed wood or charcoal as to destroy the value of the nitrogen-carbon ratio for the purpose indicated.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing soluble phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant food by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant food is concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes: Limestone provides the plant food calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much

more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by preventing the growth of certain fungus diseases, such as corn root rot. Experience indicates that it modifies directly the physical structure of some soils, frequently to their great improvement.

Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands. Remarkable success has been experienced with limestone used in conjunction with sweet clover in the reclamation of abandoned hill land which had been ruined thru erosion.

Amounts to Apply.—If the soil is acid, at least 2 tons per acre of ground limestone should be applied as an initial treatment. Continue to apply limestone from time to time according to the requirement of the soil as indicated by the tests described below, or until the most favorable conditions are established for the growth of legumes, using preferably at times magnesian limestone ($CaCO_3MgCO_3$), which contains both calcium and magnesium and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone ($CaCO_3$). On strongly acid soils, or on land being prepared for alfalfa, 4 or 5 tons per acre of ground limestone may well be used for the first application.

How to Ascertain the Need for Limestone.—The need of a soil for limestone may be ascertained by applying one of the following tests for soil acidity. Along with the acidity test, a test for the presence of carbonates should be made. It should be understood that a positive test for carbonates does not guarantee the absence of acid; for it may happen, especially when the soil is near the neutral point, that positive tests for both acidity and carbonates are obtained. This condition is explained by the assumption that solid particles of calcium or magnesium carbonates form centers of alkalinity within a soil that is generally acid. Because of this fact any test made of a given soil ought to be repeated if it is to be thoroly reliable. It is also desirable to test samples from different depths. Following are the directions for making these tests:

The Litmus Paper Test for Acidity. Make a ball of fresh moist soil, break it in two, insert a piece of blue litmus paper, and press the soil firmly together again. After a few minutes examine the paper. If it has turned pink or red, soil acidity is indicated. The intensity of the color and the rapidity with which it develops indicates to some extent the amount of acidity. Needless to say the reliability of the test depends upon the quality of litmus paper used.

The Potassium Thiocyanate Test for Acidity. A more recently discovered test fo soil acidity which promises to be more satisfactory than the litmus test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol (not denatured). When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. The conditions for a prompt reaction require a temperature that is comfortably warm.

The Hydrochloric Acid Test for Carbonates. Make a shallow cup of a ball of soil and pour into it a few drops of concentrated hydrochloric acid. If carbonates are present they are decomposed with the liberation of carbon dioxid, which appears as gas bubbles, producing foaming or effervesence. With much carbonate present the action is lively, but with mere traces of it the bubbles are given off slowly. If no carbonate, or very little, is indicated by the test, then it is advisable to apply limestone.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen costs from four to

five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for agricultural uses. *These are the chemical and the biological fixation of the atmospheric nitrogen.* Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of those legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for feed and seed as well as for nitrate production, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen, the possibilities of which now represent numerous compounds, will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes.

For easy figuring it may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy requires 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpeas contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of a soil varies according to its origin and the kind of farming practiced. Even virgin soils are found that are deficient in phosphorus.

On all lands deficient in phosphorus (except on those susceptible to serious erosion by surface washing or gullying) that element should be applied in considerably larger amounts than are required to meet the actual needs of the crops desired to be produced. The abundant information thus far secured shows positively that fine-ground natural rock phosphate can be used successfully and very profitably, and clearly indicates that this material will be the most economical form of phosphorus to use in all ordinary systems of permanent, profitable soil improvement. The first application may well be one ton per acre, and subsequently about one-half ton per acre every four or five years should be applied, at least until the phosphorus content of the plowed soil reaches 2,000 pounds per acre, which may require a total application of from 3 to 5 or 6 tons per acre of raw phosphate containing 12½ percent of the element phosphorus.

Steamed bone meal and even acid phosphate may be used in emergencies, but it should always be kept in mind that a pound of phosphorus delivered in Illinois in the form of raw phosphate (direct from the mine in carload lots), is much cheaper than the same amount in steamed bone meal or in acid phosphate, both of which cost too much per ton to permit their common purchase by farmers in carload lots, which is not the case with raw phosphate. Landowners should bear in mind the fact that phosphorus additions to the soil in amounts above the immediate crop requirements represent a permanent investment, since this element is not readily lost in the drainage water as in the case of nitrogen. It is removed from the farm thru the sale of crops, milk, and animals.

Phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the fine-ground rock phosphate be intimately mixed with the organic material as it is plowed under.

The Potassium Problem

Normal soils, in which clay and silt form a considerable part of the constituency, are well stocked with potassium, altho it exists largely in insoluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be supplied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of normal soils are concerned, that the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have practically the same power as potassium to increase crop yield in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much

potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn. but the cheaper salt, kainit, was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part perhaps because the potassium removed in the crops is mostly returned in the manure if properly cared for, and perhaps in larger part because the decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no plant food of value.

In considering the conservation of potassium on the farm it should be remembered that in average live-stock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in live-stock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by the actual crop requirements for plant food, magnesium and calcium are more limited in some Illinois soils than potassium. But with these elements we must also consider the loss by leaching.

Doctor Edward Bartow and associates, of the Illinois State Water Survey, have shown that as an average of 90 analyses of Illinois well-waters drawn chiefly from glacial sands, gravels, or till, 3 million pounds of water (about the average annual drainage per acre for Illinois) contained 11 pounds of potassium, 130 of magnesium, and 330 of calcium. These figures are very significant, and it may be stated that if the plowed soil is well supplied with the carbonates of magnesium and calcium, then a very considerable proportion of these amounts will be leached from that stratum. Thus the loss of calcium from the plowed soil of an acre at Rothamsted, England, where the soil contains plenty of limestone, has averaged more than 300 pounds a year as determined by analyzing the soil in 1865 and again in 1905. And practically the same amount of calcium was found by analyzing the Rothamsted drainage waters.

Common limestone, which is calcium carbonate ($CaCO_3$), contains, when pure, 40 percent of calcium, so that 800 pounds of limestone is equivalent to 320 pounds of calcium. Where 10 tons per acre of ground limestone was applied at Edgewood, Illinois, the average annual loss during the next ten

years amounted to 790 pounds per acre. The definite data from careful investigations seems to be ample to justify the conclusion that where limestone is needed at least 2 tons per acre should be applied every four or five years.

It is of interest to note that thirty crops of clover of 4 tons each would require 3,510 pounds of calcium, while the most common prairie land of southern Illinois contains only 3,420 pounds of total calcium in the plowed soil of an acre. Thus limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals —to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of surfur, such as exists in our common types of soil, and an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply to conditions in Illinois.

Physical Improvement of Soils

In the management of most soil types, one very important thing, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is

organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is being destroyed during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, corn stalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and corn stalks should be turned under, and not burned. Probably no form of organic matter acts more beneficially in producing good tilth than corn stalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of corn stalks is one and one-half times that of a ton of manure, and a ton of dry corn stalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the corn stalks during the winter and often rather late in the spring after the frost is out of the ground. This tramping by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The bad effect will be greater if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including a liberal use of legumes, in order to increase the organic matter of the soil either by plowing under the legume crops and

other crop residues (straw and corn stalks), or by using for feed and bedding practically all the crops raised and returning the manure to the land with the least possible loss. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations, applicable to the corn belt, which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover) or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years) ; or, in live-stock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be seeded four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Wheat (with clover)
Second year —Corn
Third year —Oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Wheat or oats (with colver)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotation

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover especially as a green manure for building up depleted soils, as well as a pasture and hay crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields Representing the More Important Types of Soil Occurring in Bureau County)

In the earlier reports of this series it was the practice to incorporate in the body of the report the results of certain experiment fields, for the purpose of illustrating the possibilities of improving the soil of various types. The information carried by such data must, naturally, be considered more or less tentative. As the fields grow older new facts develop, which in some instances may call for the modification of former recommendations. It has therefore seemed desirable to separate this experiment field data from the more permanent information of the soil survey, and embody the same in the form of a supplement to the soil report proper, thus providing a convenient arrangement for possible future revisions as further data accumulate.

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the summarized results from certain of these fields which are representative of the types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

These fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots and each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, live-stock and grain farming. *In the live-stock system,* stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in form of plant manures, including all the plant residues produced, such as corn stalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It is the plan in this latter system to remove from the land only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the live-stock system.

Rotations

Crops which are of interest in the respective localities are grown in definite rotations, and on most of the fields provision is made so that every crop in the rotation is represented every year. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. In the event of clover failure, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—All crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application are: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, the equivalent of 200 pounds of kainit. The initial application of limestone is usually 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

BROWN SILT LOAM

Several experiment fields have been conducted on brown silt loam soil at various locations in Illinois. Those located at the University have been in operation the longest and they serve well to illustrate the principles involved in the maintenance and improvement of this type of soil.

The Morrow Plots

It happens that the oldest soil experiment field in the United States is located on typical brown silt loam of the early Wisconsin glaciation, on the campus of the University of Illinois. This field was started in 1879 by George E. Morrow, who for many years was Professor of Agriculture, and these plots are known as the Morrow plots.

TABLE 1.—URBANA FIELD, MORROW PLOTS: BROWN SILT LOAM; PRAIRIE; EARLY WISCONSIN GLACIATION

Crop Yields in Soil Experiments—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
		Corn	Corn	Oats	Corn	Oats	Clover
1879–87	None	....	....	....	....	....	....
1888	None	54.3	49.5	....	....	48.6	....
1889	None	43.2	....	37.4	....	....	(4.04)
1890	None	48.7	54.3	....	....	....	(1.51)
1891	None	28.6	33.2	....	....	....	(1.46)
1892	None	33.1	....	37.2	70.2	....	....
1893	None	21.7	29.6	....	34.1	....	....
1894	None	34.8	....	57.2	....	65.1	....
1895	None	42.2	41.6	....	....	22.2	....
1896	None	62.3	....	34.5	....	....	....
1897	None	40.1	47.0	....	....	....	....
1898	None	18.1	....	....	....	....	....
1899	None	50.1	44.4	....	53.5	....	....
1900	None	48.0	....	41.5	....	....	....
1901	None	23.7	33.7	....	34.3	....	....
1902	None	60.2	....	56.3	....	54.6	....
1903	None	26.0	35.9	....	....	....	(1.11)
1904	None	21.5	....	17.5	55.3	....	....
1904	MLP	17.1	....	25.3	72.7	....	....
1905	None	24.8	50.0	....	....	42.3	....
1905	MLP	31.4	44.9	....	....	50.6	....
1906	None	27.1	....	34.7	....	....	(1.42)[1]
1906	MLP	35.8	....	52.4	....	....	(1.74)[1]
1907	None	29.0	47.8	....	80.5	....	....
1907	MLP	48.7	87.6	....	93.6	....	....
1908	None	13.4	....	32.9	....	40.0	....
1908	MLP	28.0	....	45.0	....	44.4	....
1909	None	26.6	33.0	....	....	....	(.65)[2]
1909	MLP	31.6	64.8	....	....	....	(1.73)[3]
1910	None	35.9	....	33.8	58.6	....	....
1910	MLP	54.6	....	59.4	83.3	....	....
1911	None	21.9	28.6	....	....	20.6	....
1911	MLP	31.5	46.3	....	....	38.0	....
1912	None	43.2	....	55.0	....	....	16.3[1]
1912	MLP	64.2	....	81.0	....	....	20.0[1]
1913	None	19.4	29.2	....	33.8	....	....
1913	MLP	32.0	25.0	....	47.8	....	....
1914	None	31.6	....	33.6	....	39.6	....
1914	MLP	39.4	....	58.2	....	60.4	....
1915	None	40.0	49.0	....	....	....	24.2[1]
1915	MLP	66.0	81.2	....	....	....	27.1[1]
1916	None	11.2	....	37.5	27.8	....	....
1916	MLP	10.8	....	64.7	40.6	....	....
1917	None	40.0	48.4	....	....	68.4	....
1917	MLP	78.0	81.4	....	....	86.9	....
1918	None	13.6	....	27.2	....	....	(2.58)
1918	MLP	32.6	....	59.3	....	....	(4.04)
1919	None	24.0	30.8	....	52.2	....	....
1919	MLP	43.4	66.2	....	70.8	....	....
1920	None	28.2	....	37.2	....	52.2	....
1920	MLP	54.4	....	51.6	....	69.7	....

[1]Soybeans.
[2]In addition to the hay, .64 bushel of seed was harvested.
[3]In addition to the hay, 1.17 bushels of seed were harvested.

TABLE 2.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY
Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover
		16 crops	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
1888 to 1903	None.......	39.7	41.0	44.0	48.0	47.6	(2.03)
		17 crops	*8 crops*	*9 crops*	*6 crops*	*6 crops*	*3 crops*
1904 to 1920	None.......	26.6	39.6	34.4	51.4	43.9	(1.55)[1]
	MLP.......	41.1	62.2	55.2	68.1	58.3	(2.50)[1]

[1]One crop of soybean hay.

The Morrow series now consists of three plots divided into halves and the halves are subdivided into quarters. On one plot corn is grown continuously; on the second corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904, receiving standard applications of farm manure with cover crops grown in the one-crop and two-crop systems. Phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. At the same time the rate of subsequent application of both forms of phosphorus was reduced to one-fourth the quantity, or to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per year. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre with the intention of standardizing the application to the rate of 1,000 pounds of limestone per acre per year.

FIG. 1.—CORN ON THE MORROW PLOTS IN 1910

Table 1 gives the yearly records of the crop yields, and Table 2 presents the same in summarized form.

Summarizing the data from these Morrow plots into two periods with the second period beginning in 1904 when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oats production, while the averages for the three-year system show an increase in corn yield and decreases in oats and clover. Unfortunately the numbers of crops included in these last averages are too small to warrant positive conclusions.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

The Davenport Plots

Another set of plots on the University campus at Urbana, forming a more extensive series than the Morrow plots, but of more recent origin, are the Davenport plots. Here each crop in the rotation is represented every year. These plots were laid out in 1895, but special soil treatment was not begun until 1901. They now comprize five series of ten plots each, and each series constitutes a "field" in a crop rotation system.

From 1901 to 1911 three of the series were in a three-year rotation system of corn, oats, and clover, while the remaining two series rotated in corn and oats. In 1911 these two systems were combined into a five-series field, with a crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field. The alfalfa occupies one series during a rotation of the other four crops, shifting to another series in the fifth year, thus completing the cycle of all series in twenty-five years.

The soil treatment applied to these plots has been as follows:

Legume cover crops were seeded in the corn at the last cultivation on Plots 2, 4, 6, and 8, from 1902 to 1907, but the growth was small and the effect, if any, was to decrease the returns from the regular crops. Crop residues (**R**) have been returned to these same plots since 1907. These consist of stalks and straw, and all legumes except alfalfa hay and the seed of clover and soybeans. Beginning in 1918 a modification of the practice was made in that one cutting of the red clover crop is harvested as hay. In conjunction with these residues a catch crop of sweet clover grown with the wheat is plowed under.

Manure (**M**) was applied preceding corn, at the rate of 2 tons per acre per year in 1905, 1906, and 1907; subsequently as many tons have been applied as there have been tons of air-dry produce harvested from the respective plots.

Lime (**L**) was applied on Plots 4 to 10 at the rate per acre of 250 pounds of air slaked lime in 1902, and 600 pounds of limestone in 1903. No further application was made until 1911, when the system of cropping was changed. Since that time applications of limestone have been made at the rate of one-half ton per acre per year.

Phosphorus (**P**) was applied on Plots 6 to 9 at the rate of 25 pounds per acre per annum in 200 pounds of steamed bone meal; but beginning with 1908 rock phosphate at the rate of 600 pounds per acre per annum was substi-

TABLE 3.—URBANA FIELD, DAVENPORT PLOTS: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Ten-Year Average Annual Yields—Bushels or (tons) per acre
1911-1920

Serial plot No.	Soil treatment applied	Corn	Oats	Wheat	Clover 5 crops	Soybeans 5 crops	Alfalfa
1	0	55.6	50.5	26.0	(2.42)	(1.47)	(2.43)
2	R	57.1	52.3	28.7	1.47[1]	19.8	(2.46)
3	M	66.3	61.9	28.2	(2.56)	(1.62)	(2.52)
4	RL	64.8	55.6	31.4	1.61[1]	20.3	(2.72)
5	ML	69.6	64.1	32.8	(2.90)	(1.67)	(3.03)
6	RLP	71.5	69.8	43.0	2.29[1]	23.5	(3.69)
7	MLP	73.0	68.6	40.0	(3.52)	(1.97)	(3.76)
8	RLPK	70.9	72.5	40.7	1.79[1]	25.5	(3.77)
9	MLPK	70.2	72.0	39.2	(3.40)	(2.20)	(3.73)
10	Mx5LPx5	65.9	71.4	40.6	(3.31)	(2.22)	(3.77)

[1]In addition to the clover seed, a crop of hay was harvested one year on Plots 2, 4, 6, and 8, yielding 2.38, 2.20, 2.54, and 2.39 tons, respectively.

tuted for the bone meal on one-half of each of these plots. These applications continued until 1918 when adjustments were begun, first to make the rate of application of rock phosphate four times that of the bone meal, and finally to reduce the amounts of these materials to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per annum. The usual practice has been to apply and plow under at one time all phosphorus and potassium required for the rotation.

Potassium (**K** = kalium) has been applied on Plots 8 and 9 in connection with the bone meal and rock phosphate, at the yearly rate of 42 pounds per acre, and mainly as potassium sulfate.

On Plot 10 about five times as much manure and phosphorus are applied as on the other plots, but this "extra heavy" treatment was not begun until 1906, only the usual lime, phosphorus, and potassium having been applied in previous years. The purpose in making these heavy applications is to try to determine the climatic possibilities in crop yields by removing the limitations of inadequate fertility.

It will be observed that the applications described above provide for the two rather distinct systems of farming already described. *The grain system,* in which animal manure is not produced and where the organic matter is provided by the direct return to the soil of all crop residues, is exemplified in Plots 2, 4, 6, and 8; and the *live-stock system,* in which farm manure is utilized for soil enrichment, is represented in Plots 3, 5, 7, and 9.

Table 3 shows a summary of the results obtained on the Davenport plots beginning with the year 1911, when the present cropping system was introduced.

When used in conjunction with phosphorus the crop residues and the manure appear about equally effective; but where phosphorus is not applied, the manure has been decidedly more effective, under the conditions of the experiment. It should be observed, however, in this connection, that the plowing under of clover is a very essential feature of the residues system, and that, as a matter of fact, there were five clover failures, when soybeans were substituted, during the ten years. Perhaps with a more reliable biennial legume than red clover, the results would have been more favorable for this system.

Manure
Yield: 1.43 tons per acre

Manure, limestone, phosphorus
Yield: 2.90 tons per acre

FIG. 2.—CLOVER ON THE DAVENPORT PLOTS IN 1913

By comparing Plots 2 and 3 with Plots 4 and 5, it is found that limestone has had a beneficial effect on all crops. What the financial profit amounts to depends obviously upon the market value of the crops and the cost of the limestone.

Comparing Plots 4 and 5 with Plots 6 and 7, respectively, there is found in all cases an increase in crop yield as a result of adding phosphorus. The effect on wheat is especially pronounced. Where limestone and phosphorus are applied in addition to the crop residues, an increase of 17 bushels of wheat, over the yield of the untreated land, has been obtained as a ten-year average.

The effect of adding potassium to the treatment is of much interest. Plots 8 and 9 are the same as Plots 6 and 7, respectively, except that potassium has been applied to the former. On the whole, no significant benefit is shown from the addition of potassium.

No benefit appears as the result of the extra-heavy applications of manure and phosphorus on Plot 10. In fact the corn yields are noticeably less here than on the plots receiving the normal applications of these materials.

The University South Farm

On the University South Farm, at Urbana, several series of plots devoted primarily to variety testing and other crop-production experiments are so laid out as to show the effects of certain soil treatments that have been applied.

Several different systems of crop rotation are employed and the crops are so handled as to exemplify the two general systems of farming, grain and live-stock.

The summarized results presented in Table 4 represent three different systems of cropping. The first, designated as the Southwest rotation, is to be regarded as a good rotation for general practice, on this type of soil, under Illinois conditions. This is a four-field rotation of wheat, corn, oats, and clover. The second, or North-Central rotation, consisting of corn, corn, oats, and clover, represents a system very commonly practiced; and the third or South-Central rotation, consisting of corn, corn, corn, and soybeans, must be considered as a poor rotation from the standpoint of maintaining the productiveness of the land.

TABLE 4.—URBANA FIELD, SOUTH FARM: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Southwest Rotation: Series 100, 200, 400[1]: Wheat, Corn, Oats, Clover[2]					
Soil treatment applied[6]	Corn 9 crops	Oats[3] 9 crops	Wheat[3] 8 crops	Clover[4] 3 crops	Soybeans 7 crops
RP	62.3	51.9	41.0	1.05	17.3[5]
R	51.9	46.5	26.9	1.38	16.2[5]
M	59.7	50.2	29.1	(2.28)	(1.25)
MP	64.3	55.4	43.1	(2.86)	(1.51)
RLP	60.5	57.2	41.8	.64	16.4[5]
R	49.7	49.6	25.8	.83	14.7[5]
M	55.5	54.1	27.8	(1.71)	(1.28)
MLP	64.1	59.6	43.9	(1.77)	(1.58)
North-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Oats, Clover[2]					
Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Oats 9 crops	Clover 5 crops	Soybeans 4 crops
RP	56.7	51.1	56.1	.54	16.9
R	51.7	45.2	52.0	.50	16.0
M	54.9	46.7	52.1	(2.29)	(1.60)
MP	56.5	53.4	56.9	(2.73)	(1.74)
South-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Corn, Soybeans					
Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Corn 3d year 9 crops		Soybeans 9 crops
RP	51.9	44.0	41.3		20.0
R	45.5	39.9	35.2		19.2
M	50.1	42.1	33.5		(1.59)
MP	54.5	46.7	42.0		(1.66)

[1]Results from Series 300 and 800 are omitted on account of variation in soil type.
[2]Soybeans when clover fails.
[3]Only seven crops with limestone.
[4]Only one crop with limestone.
[5]Average of five crops.
[6]All phosphorus plots received ½ ton per acre of limestone in 1903.

TABLE 5.—COMPARING PRODUCTION OF CORN IN THREE DIFFERENT ROTATION SYSTEMS
ACRE YIELDS FROM PLOTS ON THE UNIVERSITY SOUTH FARM
Twelve-Year Average (1908-1919)—Bushels per acre

Rotation	Wheat-corn-oats-legume[1]	Corn-corn-oats-legume[2]		Corn-corn-corn-legume[3]		
Treatment	Corn	1st Corn	2d Corn	1st Corn	2d Corn	3d Corn
Organic manures.	55.8	53.3	46.0	47.8	41.0	34.3
Organic manures, phosphorus.	63.2	56.6	52.3	53.2	45.3	41.6

[1]Clover 3 crops, and soybeans 7 crops.
[2]Clover 5 crops, and soybeans 5 crops.
[3]Soybeans 9 crops.

On the whole, the ''residues'' have not returned yields quite so high as those produced by the manure treatment; but, as remarked above in the discussion of the Davenport plots, the residues system has probably been at a disadvantage thru frequent clover failures. On the North-Central rotation, where conditions seem to have been more favorable for clover, there is very little difference between the effect of manure and of residues.

Residues plowed under
Yield: 35.2 bushels per acre

Residues and rock phosphate
Yield: 50.1 bushels per acre

FIG. 3.—WHEAT ON THE UNIVERSITY SOUTH FARM IN 1911

In the rotation system in which limestone is being applied, no benefit of consequence to any of the crops except oats appears from the use of this material. The test, however, has hardly been of sufficient duration to warrant final conclusions; and furthermore, the comparison may be somewhat impaired by a possible residual effect of the small application of limestone made in 1903 to all the phosphorus plots.

The results obtained from the use of phosphorus are important because this element has been applied to these plots solely in the form of raw rock phosphate. The figures in almost every case show an increase in yield where the phosphorus has been applied, and in most cases this increase is very pronounced. The wheat is especially responsive to phosphorus.

The records furnish some interesting comparisons of corn yields produced under different systems of cropping. Table 5 gives a general summary of the corn yields only, in which the results from the residues and manure treatments are averaged together as "organic manures." The highest annual acre-yields are found where corn occurs but once in a rotation. Where corn is grown twice in succession, the annual acre-yields are less; and where corn occurs three times, there is a further reduction. Also, the first crop of corn within a rotation produces more than the second, and the second crop yields more than the third. These are useful facts for consideration in connection with problems of general farm management.

Experiment Fields in Bureau County

It happens that there are two experiment fields located within the borders of Bureau county, one near La Moille and the other at Spring Valley. Both of these fields are on the brown silt loam of the early Wisconsin glaciation but the Spring Valley field represents a phase of the type that was formerly timbered.

The La Moille Field

The first experimental crops were grown on the La Moille field in 1910. Two cropping systems are being carried on. The main system is the standard rotation of wheat, corn, oats, and clover. In addition to this, a minor rotation of potatoes and alfalfa has been conducted on other plots in which potatoes occupied the land for two years and were followed by six years of alfalfa. This latter rotation was changed in 1921 to one consisting of corn, corn, wheat, and alsike clover. A diagram of the La Moille field, showing the arrangement of the plots, is presented as Fig. 4.

Table 6 shows the treatment of plots and the summarized results for the years since full treatment has been under way.

In considering these results it should be taken into account that this field is not altogether uniform. As a matter of fact some of the untreated, or check, plots are among those most favorably located, and this places upon many of the treated plots a handicap which will require time to overcome. The annual records, which are not given here in the summarized results, reveal the fact that progressive improvement is taking effect as a result of proper treatment. The increases due to proper treatment are much more marked in the later than in the earlier years, thus indicating that the treated plots are becoming better or the check plots are becoming poorer, or, what is more probable, that both of these effects are taking place.

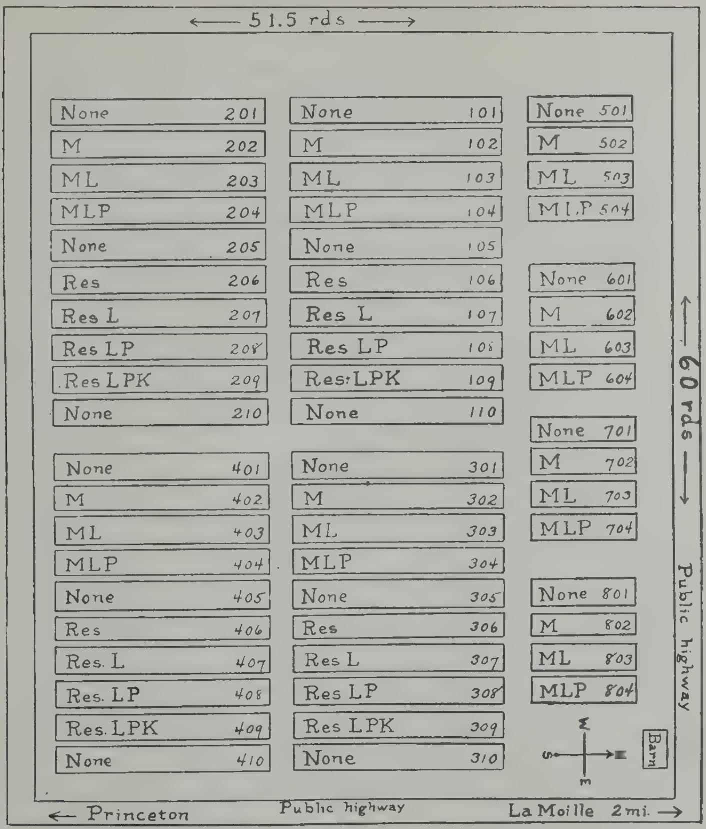


FIG. 4.—DIAGRAM SHOWING ARRANGEMENT OF PLOTS ON THE LA MOILLE EXPERIMENT FIELD.

TABLE 6.—LA MOILLE FIELD: BROWN SILT LOAM, PRAIRIE; LATE WISCONSIN GLACIATION
Average Annual Yields—Bushels or (tons) per acre

		MAIN ROTATION							MINOR ROTATION	
Serial plot No.	Soil treatment applied	Wheat	Corn	Oats	Legumes: Clover 6 crops		Soybeans 1 crop		Alfalfa	Potatoes
		6 crops	8 crops	8 crops	Hay	Seed	Hay	Seed	10 crops	8 crops
1	0.......	28.0	44.2	67.1	(2.46)	....	(2.20)	....	(2.34)	103.2
2	M......	37.9	54.4	73.7	(2.86)	....	(2.20)	....	(2.80)	135.8
3	ML.....	39.4	52.7	72.6	(2.90)	....	(2.18)	....	(2.83)	130.0
4	MLP...	39.2	53.2	70.8	(2.90)	....	(2.20)	....	(2.69)	121.8
5	0.......	36.2	39.9	59.3	(.96)	1.06	....	16 2	....	....
6	R......	38.2	48.4	72.0	(.95)	.67	....	16.8	....	....
7	RL.....	39.8	49.8	70.9	(1.05)	.73	....	16.6	....	....
8	RLP....	41.0	51.0	73.4	(1.04)	.82	....	14.4	....	....
9	RLPK..	40.9	49.1	71.1	(1.03)	.89	....	14.7	....	....
10	0.......	31.1	37.4	61.8	(2.73)	....	(1.96)	....	....	....

The data thus far obtained indicate that the addition of organic matter to the soil, whether in the form of animal manures or plant manures, has produced beneficial effects. Limestone on the whole seems to have produced no marked effect on this field. Phosphorus has as yet returned no profit when applied with manure and limestone, but when applied in the residue system gains in yield in all of the grain crops are shown. It is probable that as time goes on, and the nitrogen supply becomes built up thru the incorporation of organic matter, phosphorus will become a limiting element and greater profit will result from its use. The application of potassium has produced no significant results.

The Spring Valley Field

The Spring Valley field is located on the grounds of the Township High School. This land was formerly timbered. The surface is very rolling. In fact, the contour is so uneven as to render the plot comparisons very difficult in some cases.

The field is laid out in two rotations, a major and a minor. The major crop rotation consists of wheat, corn, oats, and clover and occupies four series of plots with 12 plots in each series. The minor rotation, on the shorter series, consists of corn, corn (for silage), and oats (with sweet clover seeding) while alfalfa occupies the fourth series. Figure 5 shows the arrangement of these plots.

Inasmuch as this field has been so recently established and so few results have been obtained since full treatment has been in effect, no attempt is made at this time to summarize the results. However, for the benefit of those who are interested in watching developments on these plots, the tabulated yields of all crops harvested up to 1921 are presented in Table 7.

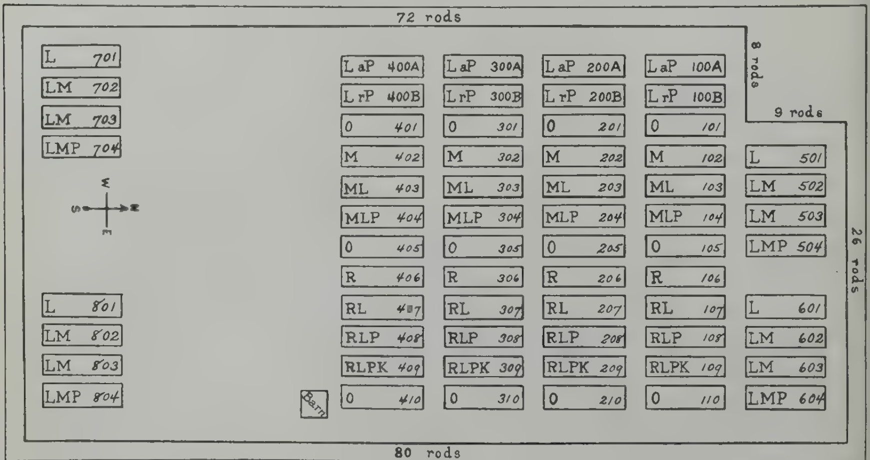


FIG. 5.—DIAGRAM SHOWING ARRANGEMENT OF PLOTS ON THE SPRING VALLEY EXPERIMENT FIELD

TABLE 7.—SPRING VALLEY FIELD: BROWN SILT LOAM, FORMERLY TIMBERED; EARLY WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1915[1]	1916	1917	1918	1919	1920
		Corn	Oats[2]	Clover[2]	Wheat[2]	Corn	Oats
100A[3]	L aP	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
100B[3]	L rP	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
101	0	34.8	35.9	(2.26)	53.2	41.6	55.3
102	M	27.8	32.5	(1.83)	46.0	42.4	51.6
103	ML	26.4	29.7	(2.36)	51.0	47.6	50.6
104	MLP	34.4	35.9	(2.40)	50.3	55.6	60.0
105	0	35.0	26.9	.03	55.3	43.6	50.6
106	R	30.4	31.2	.05	55.0	54.4	40.0
107	RL	31.2	34.4	.03	56.3	57.2	46.9
108	RLP	30.2	38.1	.05	57.2	56.8	52.2
109	RLPK	33.0	36.9	.03	49.7	66.0	58.8
110	0	35.0	35.9	(1.34)	45.2	30.8	48.1
		Wheat	Corn	Oats	Clover	Wheat	Corn
200A[3]	L aP	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
200B[3]	L rP	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
201	0	19.0	25.8	56.2	(3.84)	33.5	38.2
202	M	8.2	13.8	44.1	(4.26)	32.5	54.0
203	ML	6.3	10.4	39.1	(4.20)	32.7	53.8
204	MLP	15.5	17.8	49.7	(4.57)	34.3	55.0
205	0	15.8	14.6	40.9	(3.11) | .25	33.5	39.0
206	R	15.5	19.8	39.7	(3.37) | .42	30.8	47.4
207	RL	21.2	30.0	47.8	(3.55) | .67	33.3	50.6
208	RLP	20.8	26.2	55.6	(3.77) | 1.17	33.8	53.0
209	RLPK	18.8	25.0	42.2	(3.38) | .50	31.3	53.4
210	0	13.5	20.2	42.5	(4.56)	31.5	35.6
		Soybeans	Wheat[2]	Corn	Oats	Clover	Wheat
300A[3]	L aP	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
300B[3]	L rP	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
301	0	(1.45)	26.0	23.6	46.6	(2.87)	25.3
302	M	(1.36)	17.3	32.4	45.9	(2.94)	23.8
303	ML	(1.40)	16.3	29.6	37.5	(2.72)	26.7
304	MLP	(1.54)	21.2	44.0	50.0	(3.42)	29.3
305	0	16.5	20.7	23.8	39.4	(1.58)	21.7
306	R	17.2	17.2	46.2	54.7	(2.04)	24.3
307	RL	17.3	23.8	48.0	55.0	(2.00)	33.8
308	RLP	17.5	19.2	45.6	62.2	(1.81)	33.5
309	RLPK	17.0	14.3	50.4	50.0	(1.95)	26.7
310	0	(1.36)	16.7	20.0	35.9	(2.70)	21.2
		Oats	Clover[2]	Wheat[2]	Corn	Oats	Clover
400A[3]	L aP	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
400B[3]	L rP	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
401	0	41.2	(2.31)	36.5	54.4	36.9	(2.23)
402	M	38.4	(2.00)	33.0	58.0	38.8	(2.48)
403	ML	23.1	(1.92)	32.8	57.2	39.1	(2.22)
404	MLP	34.7	(2.33)	38.2	63.6	40.9	(2.50)
405	0	33.8	.10	35.0	50.4	36.6	(1.46) | 1.40
406	R	28.8	.17	37.3	57.2	34.7	(1.58) | 1.87
407	RL	38.1	.12	39.3	67.6	54.1	(1.58) | 1.95
408	RLP	32.5	.15	41.8	64.0	45.9	(1.68) | 2.02
409	RLPK	38.8	.15	39.0	76.8	48.8	(1.47) | 1.87
410	0	31.9	(2.33)	35.0	59.2	45.6	(2.39)

[1]Lime only. [2]No manure.

[3]In 1917 Plots A and B were added to each of the four series from 100 to 400 for the purpose of making a comparative phosphorus test. The treatment for this test was not begun until 1921. This treatment is as follows: on Plot A of each series, acid phosphate at the rate of 200 pounds per acre per year; on Plot B, finely ground rock phosphate at the rate of 400 pounds per acre per year; on both A and B, limestone at the rate of 500 pounds per acre per year, which is one-half of the usual rate.

An analysis of these yields shows that increasing gains for the better treatments are already being obtained, thus indicating that as time goes on the differences between the treated plots and the check plots will become more and more pronounced.

While it is far too early to draw final conclusions it is of interest to note a few points which the experiments seem to indicate. The possibility of building up this land thru the use of legumes and crop residues in connection with the application of limestone is already becoming apparent. While it is doubtful whether the gains produced by phosphorus are sufficient as yet to represent actual financial profit, it is altogether probable that the results will become more favorable for phosphorus as time goes on. As to the effect of potassium on this soil, it is clear that in the system of farming practiced, this material has been applied at a financial loss.

BLACK CLAY LOAM

The Hartsburg experiment field, representing black clay loam of the middle Illinoisan glaciation, is located in Logan county just east of Hartsburg. The work was begun here in 1913. There are five series of ten plots each. A crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field, is practiced. The soil treatments are as indicated in Table 8. The table also summarizes the yields, by crops, for the period during which the plots have been under full treatment.

Under the conditions of these experiments, residues alone have proved to be more effective than manure alone in the production of wheat, corn, and oats.

Limestone used with manure has given such greatly increased yields as to leave no doubt about the profitableness of its use. When applied with residues, however, there appears to be on the whole little advantage from the use of limestone.

TABLE 8.—HARTSBURG FIELD: BLACK CLAY LOAM, PRAIRIE; MIDDLE ILLINOISAN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat 5 crops	Corn 8 crops	Oats 7 crops	Clover 4 crops	Soybeans 2 crops	Alfalfa 8 crops[1]
1	0	22.6	43.4	45.4	(1.98)	(1.29)	(3.30)
2	M	27.4	48.3	50.2	(2.41)	(1.64)	(3.61)
3	ML	34.2	56.9	57.9	(2.51)	(1.82)	(3.83)
4	MLP	38.2	56.0	57.3	(2.62)	(1.92)	(4.04)
5	0	33.3	46.8	43.8	.74[2]	25.8	(3.19)
6	R	34.0	58.2	55.6	1.22[2]	26.8	(3.60)
7	RL	32.0	63.7	54.9	1.32[2]	28.4	(3.28)
8	RLP	36.4	61.1	59.0	1.41[2]	26.1	(3.83)
9	RLPK	35.2	59.5	57.2	1.42[2]	26.4	(4.01)
10	0	31.7	46.7	46.9	(2.14)	(1.69)	(3.02)

[1]No residues except on last two crops.
[2]In addition to the clover seed, hay was harvested on Plots 5, 6, 7, 8, and 9 amounting to .56, 1.01, 1.11, 1.20, and 1.03 tons, respectively.

Phosphorus has given good returns on the wheat crop, but with the other crops its recommendation would be doubtful. In this connection attention should be called to the fact that chemical analysis of this black clay loam type generally shows a relatively high phosphorus content. The experience on this field seems to bear out what the analyses show.

The addition of potassium has produced a depressing effect on the yields of all grain crops, and with the alfalfa the small gain could scarcely be considered significant.

YELLOW-GRAY SILT LOAM

Yellow-gray silt loam exhibits an important variation with respect to limestone content. In some areas, altho limestone may be altogether absent in the surface stratum it is found in abundance at a short distance beneath the surface. Accordingly, variations in response to soil treatment are exhibited by different experiment fields located on this type. In view of this discrepancy it is thought well to introduce here the records of two fields, that are representative of the type but which show a marked diversity in results, one in northern Illinois and one in the southern part of the state.

The Antioch field is located on the late Wisconsin glaciation, in Lake county, close to the Wisconsin border. The field was started in 1902, with but a single series of ten plots, under a rotation of corn, corn, oats, and wheat; but beginning with 1911 the rotation has been wheat, corn, oats, and clover. It was started in order to learn as quickly as possible what effect would be produced by the addition to this type of soil of nitrogen, phosphorus, and potassium, used singly and in combination. These elements were all applied in commercial form until 1911, after which the use of commercial nitrogen was discontinued and crop residues were substituted in its place. Nitrogen was supplied in the earlier years in 800 pounds per acre of dried blood. Phosphorus is applied in 200 pounds of steamed bone meal, and potassium in 100 pounds of potassium sulfate. At the beginning, 470 pounds of slaked lime was applied; but since 1912 limestone has been applied at the rate of 1,000 pounds per acre per year.

TABLE 9.—ANTIOCH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LATE WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 8 crops	Oats 5 crops	Wheat 4 crops	Clover seed 2 crops
1	0	23.9	32.3	15.8	.50
2	L	21.3	26.8	13.2	.30
3	LR	21.3	29.9	20.6	.33
4	LP	30.7	43.6	36.7	1.08
5	LK	23.7	27.8	19.2	.57
6	LRP	33.8	43.3	33.3	.57
7	LRK	24.3	26.9	20.8	.59
8	LPK	25.1	38.2	30.9	1.26
9	LRPK	38.3	42.6	28.0	.33
10	RPK	38.4	44.7	30.2	.67

Manure, limestone, phosphorus
Yield: 61 bushels per acre

Nothing applied
Yield: 15 bushels per acre

FIG. 6.—CORN ON RALEIGH FIELD IN 1920

Table 9 presents, in summarized form, the results from the Antioch field. Because of an abnormality in Plot 1, the results from this plot are not considered. The data show that phosphorus is the one element standing out prominently as producing consistently beneficial results. Potassium applied in addition to phosphorus has, on the whole, not produced profitable results. Also, the results are unfavorable for the application of limestone. Limestone, however, is abundant in the subsoil of this type in the region of this field.

The Raleigh experiment field is located on the lower Illinoisan glaciation, in southern Illinois, in Saline county. This field is laid out into four series of ten plots each, under a rotation of wheat, corn, oats, and clover. The treatments, along with the summarized results, are given in Table 10.

The outstanding feature of these results is the effect of limestone. Altho manure alone produces a substantial increase, especially in the corn crop, when limestone is added a remarkable increase is found in all crops. A most important fact is that the organic matter can be effectively built up thru the use of crop residues, with the application of limestone, so that the crop yields are practically as high under this "grain system" of farming as where manure is used.

Phosphorus thus far has given only moderate returns in increased crop yields, but with an increasing quantity of organic matter and nitrogen it is probable that the phosphorus applications will show up more favorably on subsequent crops. As to the use of potassium, it is to be noted that aside from an increase of 5.4 bushels of corn in the residues system, the beneficial effect has not been sufficient to justify the use of this material.

TABLE 10.—RALEIGH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LOWER ILLINOISAN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 10 crops	Oats 10 crops	Wheat 6 crops	Clover 4 crops		Soybeans 4 crops
1	0................	17.3	10.4	5.8	(.26)		(.65)
2	M................	29.7	13.0	7.7	(.31)		(.81)
3	ML................	40.9	20.0	21.0	(1.08)		(1.08)
4	MLP...............	41.2	20.3	21.5	(1.32)		(1.24)
5	0................	17.3	10.3	7.0	(.00)	.01[2]	2.3
6	R................	20.1	12.8	8.4	(.00)	.01[2]	3.0
7	RL................	34.9	21.5	18.8	(1.60)[1]	.10[2]	5.8
8	RLP...............	36.5	22.7	21.2	(1.61)[1]	.09[2]	6.8
9	RLPK..............	41.9	23.6	22.4	(1.79)[1]	.12[2]	6.0
10	0................	19.6	11.6	6.5	(1.06)		(.57)

[1]One crop only (1920).
[2]Average of two crops.

In accounting for the discrepancy in the response to limestone on these two fields, the fact is to be considered that the Antioch field is located on the late Wisconsin glaciation, where the subsoil contains large quantities of limestone; while the Raleigh field represents the lower Illinoisan glaciation, the soil of which is very acid to a great depth.

In view of these variations, a general recommendation for a complete treatment for soil of this type, that will apply to all localities, cannot be given out until more information is acquired.

Fortunately, however, each farmer can determine for himself the need of limestone for his land by applying the simple tests for the presence of carbonates and soil acidity, as explained under the discussion of limestone on page 43 of the Appendix.

Phosphorus, which has paid well on the Antioch field, and has given doubtful returns thus far at Raleigh, has varied considerably in its effect when used on other fields located on this same type of soil. In this situation, therefore, the present suggestion would be that each farmer might well try out phosphorus on his own land, on a limited scale, and be guided by the outcome of his experience. The low phosphorus content of the surface stratum of this soil is an indication that in a system of permanent agriculture the time is not far off when phosphorus will become a limiting element to crop production, and the wise farmer will watch carefully the indications and be ready to make timely provision for this need.

YELLOW SILT LOAM

A soil fertility experiment field on yellow silt loam is located at Elizabethtown, in the southern end of the state, but this field has not been in operation long enough to furnish results that can be used.

FIG. 7.—WHEAT IN POT-CULTURE EXPERIMENT WITH YELLOW SILT LOAM OF WORN HILL LAND
The need of nitrogen (N) on this type of soil is clearly demonstrated.

TABLE 11.—CROP YIELDS IN POT-CULTURE EXPERIMENT WITH YELLOW SILT LOAM OF WORN HILL LAND

Grams per pot

Pot No.	Soil treatment applied	Wheat	Oats
1	None	3	5
2	Limestone	4	4
3	Limestone, nitrogen	26	45
4	Limestone, phosphorus	3	6
5	Limestone, potassium	3	5
6	Limestone, nitrogen, phosphorus	34	38
7	Limestone, nitrogen, potassium	33	46
8	Limestone, phosphorus, potassium	2	5
9	Limestone, nitrogen, phosphorus, potassium	34	38
10	None	3	5
Average yield with nitrogen		32	42
Average yield without nitrogen		3	5
Average gain for nitrogen		29	37

However, some experiments in pot culture have been conducted with soil of this type, the results of which furnish useful data in indicating the proper management of this kind of soil.

In one experiment a large quantity of typical worn hill soil was collected from two different places. Each lot of soil was thoroly mixed and put into ten four-gallon jars. Wheat was planted in one series and oats in the other. Ground limestone was added to all the jars except the first and last in each set, those two being retained as control, or check pots. The elements nitrogen, phosphorus, and potassium were added singly and in combination, as shown in Table 11.

As an average, the yield produced where nitrogen was applied, was about eight times as large as that secured without the addition of nitrogen.

But there is no need whatever to purchase nitrogen, for the air contains an inexhaustible supply of it which, under suitable conditions, the farmer can draw upon, not only without cost, but with profit in the getting. Clover, alfalfa,

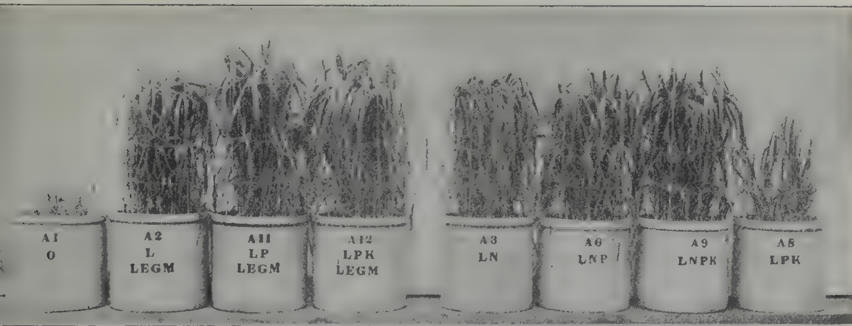


FIG. 8.—WHEAT IN POT-CULTURE EXPERIMENT WITH YELLOW SILT LOAM OF WORN HILL LAND

In the pots at the right, nitrogen is applied in commercial form. In the pots at the left, nitrogen is secured from the air thru the growing of legumes.

TABLE 12.—CROP YIELDS IN POT-CULTURE EXPERIMENT WITH YELLOW SILT LOAM OF WORN HILL LAND AND NITROGEN-FIXING GREEN MANURE CROPS

Grams per pot

Pot No.	Soil treatment applied	1903 Wheat	1904 Wheat	1905 Wheat	1906 Wheat	1907 Oats
1	None	5	4	4	4	6
2	Limestone, legume	10	17	26	19	37
11	Limestone, legume, phosphorus	14	19	20	18	27
12	Limestone, legume, phosphorus, potassium	16	20	21	19	30
3	Limestone, nitrogen	17	14	15	9	28
6	Limestone, nitrogen, phosphorus	26	20	18	18	30
9	Limestone, nitrogen, phosphorus, potassium	31	34	21	20	26
8	Limestone, phosphorus, potassium	3	3	5	3	7

sweet clover, cowpeas, and soybeans are worth raising not only because of their value as crops but because of their power, when properly inoculated with nitrogen-fixing bacteria, to secure nitrogen from the atmosphere.

In order to secure further information concerning the best practice in building up the nitrogen content, another experiment with pot cultures was conducted for several years with the same kind of worn hill soil as that used for wheat in the former experiment. The results are reported in Table 12.

To three pots (Nos. 3, 6, and 9) nitrogen was applied, in commercial form, at an expense amounting to more than the total value of the crops produced. In three other pots (Nos. 2, 11, and 12) a crop of cowpeas was grown during the late summer and fall and turned under before the wheat or oats were planted. Pots 1 and 8 served for important comparisons. After the second cover crop of cowpeas had been turned under, the yield from Pot 2 exceeded that from Pot 3; and in the subsequent years the green manure from legumes produced, as an average, somewhat better results than the commercial nitrogen. This experiment confirms the previous one in showing the very great need for nitrogen for the improvement of this type of soil—and it also shows that nitrogen need not be purchased but that it can be obtained from the air by growing legume

crops and plowing them under as green manure. Of course the soil can be very markedly improved by feeding the legume crops to live stock and returning the resulting farm manure to the land, if legumes are grown frequently enough and if the farm manure produced is sufficiently abundant and is saved and applied with care.

It may not be advisable in all cases to enrich this type of soil in phosphorus, for with erosion, which is sure to occur to some extent, the phosphorus supply will be renewed from the subsoil.

Probably the best legumes for this type of soil are sweet clover and alfalfa. On soil deficient in organic matter, sweet clover grows better than almost any other legume, and the fact that it is a very deep-rooting plant makes it of value in increasing the organic matter and in preventing washing. Worthless slopes, where the land has been ruined by washing, may be made profitable as pasture by growing sweet clover. The blue grass of pastures may well be supplemented by sweet clover and alfalfa, and a larger growth obtained, because the legumes provide the necessary nitrogen for the blue grass.

To get alfalfa started well requires the liberal use of limestone, thoro inoculation with nitrogen-fixing bacteria, and a moderate application of farm manure. If manure is not available, it is well to apply about 500 pounds per acre of acid phosphate or steamed bone meal, mix it with the soil, by disking if possible, and then plow it under. The limestone (about 5 tons) should be applied after plowing and should be mixed with the surface soil in the preparation of the seed bed. The special purpose of this treatment is to give the alfalfa a quick start in order that it may grow rapidly and thus protect the soil from washing.

DUNE SAND

In 1913 the University came into possession of a tract of dune sand on terrace, in Henderson county, near the Mississippi river, upon which an experiment field was laid out to determine the needs of these sand soils. This field is divided into six series of plots. Corn, soybeans, wheat, sweet clover, and rye, with a catch crop of sweet clover seeded in the rye on the residues plots, are grown in rotation on five series, while the sixth series is devoted to alfalfa. When sweet clover seeded in the wheat fails, cowpeas are substituted.

No catch of alfalfa or of sweet clover was obtained till the alfalfa drill was used in seeding. This covers the seed about one-half inch deep.

Table 13 indicates the kinds of treatment applied, the amounts of the materials used being in accord with the standard practice, as explained on page 52.

The data make apparent the remarkably beneficial action of limestone on this sand soil. Where limestone has been used in conjunction with crop residues, the yield of corn has been doubled. The limestone has also produced a fair crop of rye and excellent crops of sweet clover and alfalfa.

This land appears to be quite indifferent to phosphorus treatment. The analysis shows, however, that the stock of phosphorus in this type of soil is not large, and it may develop as time goes on and the supply diminishes along with the production of good-sized crops, that the application of this element will become profitable.

Manure
Yield: Nothing

Manure and limestone
Yield: 4.43 tons per acre

FIG. 9.—ALFALFA ON OQUAWKA FIELD IN 1918

Altho the results show an increase of 3.4 bushels of corn from the use of otassium salts, with ordinary prices this would not be a profitable treatment. The .64 bushel gain in sweet-clover seed is the average of two crops only, and his is insufficient data upon which to base conclusions. The other crops all how negative results from the potassium application.

Experience thus far shows rye to be better adapted to this land than wheat, nd both alfalfa and sweet clover thrive better than soybeans. With these two

TABLE 13.—OQUAWKA FIELD: DUNE SAND, TERRACE
Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 6 crops	Soy-beans[1] 5 crops	Wheat 6 crops	Sweet clover 4 crops	Rye 4 crops	Alfalfa 3 crops
1	0	14.3	(.89)	6.4	0	12.1	(.11)
2	M	18.9	(1.01)	8.1	0	13.3	(.13)
3	ML	23.4	(1.27)	9.7	(1.20)	20.1	(1.88)
4	MLP	22.2	(1.20)	10.1	(1.26)	19.5	(2.03)
					2 crops 2 crops		
5	0	14.4	3.5	7.4	(0) 0	13.7	(.14)
6	R	16.2	3.5	8.1	(0) 0	14.1	(.12)
7	RL	29.3	6.6	9.1	(1.47) 2.53	23.2	(2.05)
8	RLP	29.3	6.4	10.4	(1.39) 2.20	24.2	(1.90)
9	RLPK	32.7	6.0	9.4	(1.53) 2.84	23.7	(1.86)
10	0	11.4	(.60)	6.4	(0)	10.6	(.06)

[1] In 1918 sweet clover was killed by being cut for hay. Soybeans were seeded on these plots nd the following yields obtained: .86, 1.10, 1.93, and 2.00 tons of hay per acre on Plots 1 to 4; 1.1, 9.9, 14.6, 15.8, and 16.6 bushels of seed per acre on Plots 5 to 9; and .62 ton of hay per acre n Plot 10.

legume crops thriving so well under this simple treatment, we have promise of tremendous possibilities for the profitable culture of this land, which hitherto has been considered as practically worthless.

Deep Peat

As representing the deep peat type of soil, the results are introduced from an experiment field conducted at Manito in Mason county during the years 1902 to 1905 inclusive.

There were ten plots receiving the treatments indicated in Table 14.

The results of the four years' tests, as given in Table 14, are in complete harmony with the information furnished by the chemical composition of peat soil. Where potassium was applied, the yield was from three to four times as large as where nothing was applied. Where approximately equal money values of kainit and potassium chlorid were applied, slightly greater yields were obtained with the potassium chlorid, which, however, supplied about one-third more potassium than the kainit. On the other hand, either material furnished more potassium than was required by the crops produced.

The use of 700 pounds of sodium chlorid (common salt) produced no appreciable increase over the best untreated plots, indicating that where potassium is itself actually deficient, salts of other elements cannot take its place.

Applications of 2 tons per acre of ground limestone produced no increase in the corn crops, either when applied alone or in combination with kainit, either the first year or the second.

Reducing the application of kainit from 600 to 300 pounds for each two-year period reduced the yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainit (Plot 9) furnished 60 pounds of potassium for the four years, an amount sufficient for 84 bushels of corn (grain and stalks). Attention is called to the fact that this is practically the difference between the yield of Plot 9 (125.9 bushels) and the yield obtained from Plot 2 (42.9 bushels), the poorest untreated plot.

TABLE 14.—MANITO FIELD: DEEP PEAT
Corn Yields—Bushels

Plot No.	Soil treatment for 1902	Corn 1902	Corn 1903	Soil treatment for 1904	Corn 1904	Corn 1905	Four crops
1	None	10.9	8.1	None	17.0	12.0	48.0
2	None	10.4	10.4	Limestone, 4000 lbs.	12.0	10.1	42.9
3	Kainit, 600 lbs	30.4	32.4	Limestone, 4000 lbs.; Kainit, 1200 lbs	49.6	47.3	159.7
4	Kainit, 600 lbs.; Acidulat'd bone, 350 lb.	30.3	33.3	Kainit, 1200 lbs; Steamed bone, 395 lbs.	53.5	47.6	164.7
5	Potassium chlorid, 200 lbs	31.2	33.9	Potassium chlorid, 400 lbs	48.5	52.7	166.3
6	Sodium chlorid, 700 lbs.	11.1	13.1	None	24.0	22.1	70.3
7	Sodium chlorid, 700 lbs.	13.3	14.5	Kainit, 1200 lbs	44.5	47.3	......
8	Kainit, 600 lbs	36.8	37.7	Kainit, 600 lbs	44.0	46.0	164.5
9	Kainit, 300 lbs	26.4	25.1	Kainit, 300 lbs	41.5	32.9	125.9
10	None	14.9[1]	14.9	None	26.0	13.6	69.4

[1]Estimated from 1903; no yield was taken in 1902 because of a misunderstanding.

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT NO. 21

McHENRY COUNTY SOILS

By J. G. MOSIER, R. W. DICKENSON, H. W. STEWART, E. VAN ALSTINE
and H. J. SNIDER

Prepared for publication by L. H. SMITH

URBANA, ILLINOIS, DECEMBER, 1921

IN RECOGNITION

The Soil Survey of Illinois was organized under the supervision of the late Dr. Cyril G. Hopkins. The work progressed for eighteen years under his guidance and the first eighteen soil reports bear his name as senior author. On October 6, 1919, Dr. Hopkins died in a foreign land in the service of the American Red Cross. It is the purpose to carry on to completion this great work of the Illinois Soil Survey in the spirit, and along the same general plan and lines of procedure, in which it was begun.

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INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or land owner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and land owner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

CONTENTS OF SOIL REPORT No. 21

McHENRY COUNTY SOILS

APPENDIX

SUPPLEMENT

McHENRY COUNTY SOILS

By J. G. MOSIER, R. W. DICKENSON, H. W. STEWART, E. VAN ALSTINE
and H. J. SNIDER

Prepared for publication by L. H. SMITH[1]

FORMATION

McHenry county is situated in the northern part of Illinois about 18 miles west of Lake Michigan. It lies in the Iowan and late Wisconsin glaciations, the latter covering the east three-fourths of the county. It has an area of 609.5 square miles.

During the Glacial period, snow and ice accumulated in the region of Labrador and to the west of Hudson Bay to such an extent that the mass pushed outward from these centers, chiefly southward, until a point was reached where it melted as rapidly as it advanced. In moving across the country the ice gathered up all sorts and sizes of material, including clay, silt, sand, gravel, small and large boulders, and even large masses of rock. Many of these were carried for hundreds of miles and the coarser materials were rubbed against surface rocks or against each other until largely ground into powder. When, thru the melting of the ice, the limit of advance was reached, the material carried by the glacier accumulated in a broad, undulating ridge or moraine. Much of the finer material was carried away in the drainage from the glacier and deposited on level outwash plains or over the flood plains of streams. When the ice melted more rapidly than the glacier advanced, the terminus of the glacier would recede and the material would be deposited somewhat irregularly over the area previously covered. This is known as the ground moraine, or intermorainal tract. A glacier receded and advanced a number of times, and with each advance another moraine was formed. The intermorainal tracts are now occupied chiefly by level, undulating, or slightly rolling plains.

The material transported by the glacier varied with the character of the rocks over which it passed. Granites, limestones, sandstones, shales, etc., were torn from their lodging places by the tremendous denuding power of the ice sheet and ground up together, the softer rocks disappearing first. A pressure of forty pounds per square inch is exerted by a mass of ice one hundred feet thick, and these ice sheets were hundreds or even thousands of feet in thickness. The materials carried along in the ice, especially the boulders and pebbles, became powerful agents for grinding and wearing away the surface over which the ice passed. Preglacial ridges and hills were rubbed down, valleys were filled with the debris, and the surface features were changed entirely. The mixture of material deposited by the glacier is known as boulder clay, till, glacial drift, or simply drift.

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[1] J. G. Mosier, in charge of soil survey mapping; R. W. Dickenson and H. W. Stewart, in charge of field party; E. Van Alstine, in charge of soil analysis; H. J. Snider, in charge of experiment fields; L. H. Smith, in charge of publications.

THE GLACIATIONS OF McHENRY COUNTY

The first glacier to cover McHenry county was the Illinoisan, which covered all of Illinois except the northwest county, the southern part of Calhoun county, and the seven southernmost counties. The deposit left by this glacier was covered by the deposit of subsequent glaciers, and therefore does not form the surface soil at any place in McHenry county. The next glacier was the Iowan, which covered the northeastern part of the state, but most of the deposit left by this was also covered by deposits from some of the later glaciers.

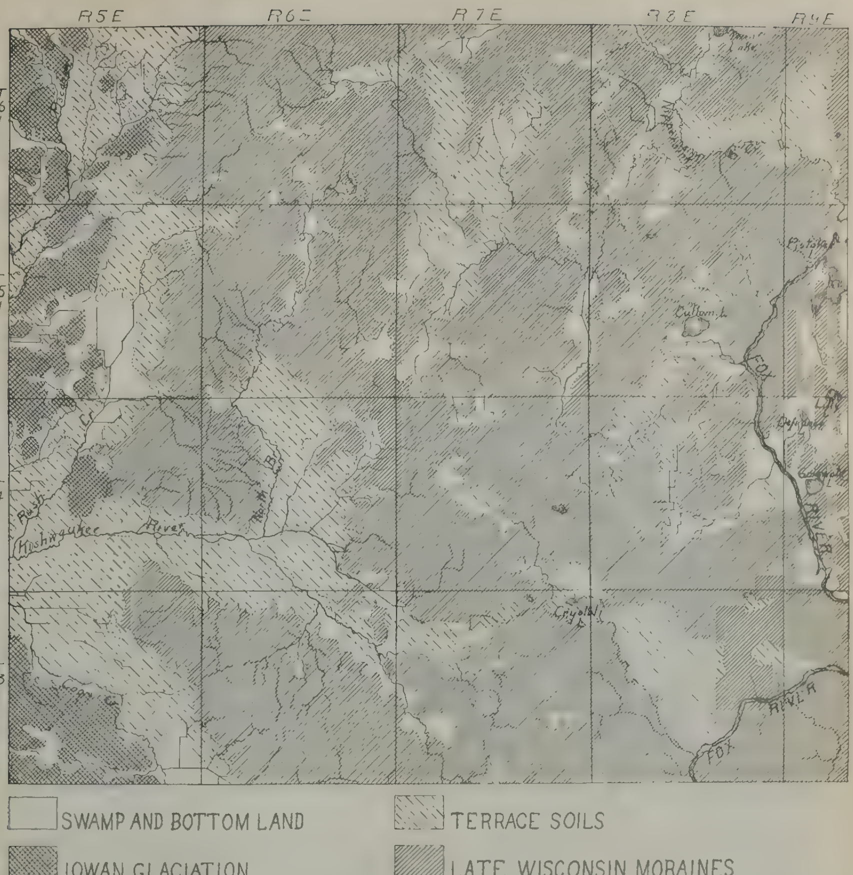
Two glaciations form the present surface deposits: the Iowan, and the late Wisconsin. The Iowan occurs in the western part of the county and covers the larger part of Town 46 North, Range 5 East; the west half of Town 45 North, Range 5 East; approximately the west four tiers of sections in Town 44 North; and a small area in the southwest part of the county in Town 43 North, Range 5 East. Without doubt the early Wisconsin glacier covered part of McHenry county, but the late Wisconsin has buried the early Wisconsin drift so that it cannot be distinguished. The late Wisconsin contains a very extensive morainic system known as the Valparaiso moraine. The drift in the county is rarely less than 50 feet in thickness, and the average depth is not less than 200 feet.

Large areas of gravel outwash, formed by broad, shallow, swift streams flowing from the melting glacier, and mapped as terraces, are found in the west and southwest parts of the county. Another large area occurs to the south of Hebron, another east of Spring Grove, and still another south of Crystal Lake. These terraces furnish large quantities of gravel that are very valuable for road material and concrete work. Much of the area of the county is covered by a thin layer of loessial or wind-blown material.

PHYSIOGRAPHY AND DRAINAGE

The county varies widely in topography, the terrace and swamp lands being generally level, while the upland, especially that of the late Wisconsin glaciation, is decidedly rolling. The variations are principally due to the irregular deposition of glacial material in the moraines. The morainic areas are characterized by a peculiar billowy appearance produced by the large number of rounded knobs, and kettle-holes, or basin-like depressions, that vary in depth from 2 or 3 feet to 50 feet or more and in diameter from a few rods to 20 rods. A few lakes are found, the largest of which is the Pistakee, which extends over from Lake county. Some rock outcrop occurs in the western part of the county along the Kishwaukee river. Many swamps are found all over the county, and the kettle-holes on the moraines are frequently occupied by ponds. The western part of the county is drained by the Kishwaukee and its tributaries, while the eastern is drained by the Fox river and the Nippersink creek.

The altitudes of some places in McHenry county are as follows: Alden, 964 feet above sea level; Algonquin, 760; Big Foot Prairie, 950; Cary, 811; Chemung, 877; Coral, 875; Coyne, 885; Crystal Lake, 922; Greenwood, 820; Harmony, 910; Hartland, 924; Harvard, 935; Hebron, 931; Huntley, 888; Johnsburg, 790; Lawrence, 896; McHenry, 770; Marengo, 819; Richmond, 815; Ridgefield, 928; Ringwood, 837; Solon Mills, 792; Spring Grove, 781; Terra Cotta, 807; Union, 836; Woodstock, 916.



MAP SHOWING THE DRAINAGE BASINS OF McHENRY COUNTY WITH MORAINAL, TERRACE, BOTTOM-LAND, AND SWAMP AREAS

SOIL MATERIAL AND SOIL TYPES

The soils of the Iowan glaciation are not formed from the glacial drift left by that glacier, but from a deposit of wind-blown or loessial material varying in depth from 3 to 8 feet. The area covered by the late Wisconsin glacier does not have such a deep deposit of loess, and in some cases the soil was formed directly from glacial material. Usually, however, the glacial material is not found until a depth of 18 to 24 inches is reached. A large number of small areas of gravelly loam occur, many of which are not large enough to be shown on the map.

In general the glacial material of these moraines contains much more gravel than is found in the counties to the south. The outwash sand and gravel plains have been covered with finer material to a depth of 20 to 50 inches and constitute excellent soils. About one-fourth of the area of the county is swamp and

bottom-land. The accumulation of organic matter on this area has gone on to such an extent that the soils are very rich in this constituent.

The soils of McHenry county are divided into the following classes:

(a) Upland Prairie Soils.—These are rich in organic matter. This land was originally covered with wild prairie grasses, the partially decayed roots of which have been the source of the organic matter. The flat prairie land contains a higher amount of this constituent than the undulating or rolling prairie, because the grasses and roots grew more luxuriantly there, and being saturated with water they were preserved from complete decay.

TABLE 1.—SOIL TYPES OF MCHENRY COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (700, 1000, 1200)			
-26	Brown silt loam	120.08	76,851	19.70
-60	Brown sandy loam	28.24	18,074	4.63
-90	Gravelly loam	4.73	3,027	.78
		153.05	97,952	25.11
	(b) Upland Timber Soils (700, 1000, 1200)			
-34	Yellow-gray silt loam	130.04	83,226	21.34
-35	Yellow silt loam	4.92	3,149	.81
-64	Yellow-gray sandy loam	43.82	28,045	7.19
-65	Yellow sandy loam	1.10	704	.18
		179.88	115,124	29.52
	(c) Terrace Soils (1500)			
1527	Brown silt loam over gravel	45.93	29,395	7.54
1526.4	Brown silt loam on gravel	6.81	4,358	1.12
1525	Black silt loam	1.67	1,069	.27
1566	Brown sandy loam over gravel	8.41	5,382	1.38
1560.4	Brown sandy loam on gravel	31.31	20,039	5.14
1536	Yellow-gray silt loam over gravel	13.85	8,864	2.27
1534.4	Yellow-gray silt loam on gravel	5.88	3,763	.96
1567	Yellow-gray sandy loam over gravel	1.37	877	.22
1564.4	Yellow-gray sandy loam on gravel	4.21	2,694	.69
1528	Brown-gray silt loam on tight clay	.03	19	.004
1590	Gravelly loam	1.00	640	.16
		120.47	77,100	19.75
	(d) Late Swamp and Bottom-Land Soils (1400)			
1450	Black mixed loam	104.45	66,848	17.14
1450.2	Black mixed loam on sand	6.48	4,147	1.06
1401	Deep peat	36.74	23,514	6.03
1402.2	Medium peat on sand	.78	499	.13
1454	Mixed loam	2.69	1,722	.44
		151.14	96,730	24.80
	(e) Miscellaneous			
	Water	4.21	2,694	.69
	Gravel pits	.77	493	.13
		4.98	3,187	.82
	Total area	609.52	390,093	100.00

The upland prairie soils include some areas of recent timber growth where certain kinds of trees have spread over the prairie, but this forestation has not been of sufficient duration to produce the characteristic timber soils. These areas of greater or less width are found along the border of most timber tracts, so that the timber actually extends a little farther than the soil type would indicate.

(b) Upland Timber Soils.—These include a large part of the upland that was formerly covered with forests. These soils contain much less organic matter than the prairie soils because the large roots of dead trees added but little, and the surface accumulations of leaves, twigs, and fallen trees were burned by forest fires or suffered almost complete decay. The timber lands are divided chiefly into two classes—the undulating and the hilly areas.

(c) Terrace Soils.—These include outwash sand and gravel plains, bench lands or second bottom lands, formed by deposition from overloaded streams during the melting of the glacier and subsequent to that time. Finer deposits which were later made upon the coarse, gravelly material now constitute the soil.

(d) Late Swamp and Bottom-Land Soils.—These include the overflow lands, or flood plains of streams, and the very poorly drained lowlands where peats, peaty loams, and mucks have been formed. The organic matter of these soils is derived largely from swamp mosses with grasses as a secondary source.

(e) Miscellaneous.—This includes the area occupied by water, rock outcrops, and gravel pits.

Table 1 shows the area of each type of soil in McHenry county in square miles and in acres, and its percentage of the total area. The accompanying map shows the location and boundary lines of the various types, even down to areas of a few acres.

For explanations concerning the classification of soils and the interpretation of the map and tables the reader is referred to the first part of the Appendix to this report.

INVOICE OF PLANT FOOD IN McHENRY COUNTY SOILS

SOIL ANALYSIS

The composition reported in the accompanying tables is, for the more extensive types, the average of several analyses. These analyses, like most things in nature, show more or less variation, but for general purposes the averages may be considered sufficient to characterize the soil type.

The chemical analysis of a soil by the methods here employed gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed, but it should be understood that the rate of liberation, as explained in the Appendix, page 27, is governed by many factors.

THE SURFACE SOIL

In Table 2 are reported the amount of organic carbon, which is a measure of the organic matter, and the total quantities of nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium contained in 2 million pounds of the surface soil (the plowed soil of an acre about 6⅔ inches deep) of each type in McHenry

county. Because of the inadequacy of information furnished by mere averages with respect to limestone content and soil acidity, these figures are not included in the tabulated results. For a more complete explanation of this point see note in the tables.

The variation among the different types of soil with respect to the content of important plant-food elements is very marked. For example, the deep peat contains, in the plowed soil of an acre, nearly 30 times as much nitrogen as does the yellow-gray sandy loam. Comparing the deep peat with the most common type in the county, we find about 18 times as much nitrogen in the deep peat as in the yellow-gray silt loam, while on the other hand the yellow-gray silt loam contains about 18 times as much potassium as is found in the deep peat. The supply of phosphorus in the surface soil varies from 580 pounds per acre in the yellow-gray sandy loam to 3,380 pounds in the mixed loam. A sulfur content of 5,500 pounds per acre is found in the deep peat, while in the yellow-gray sandy loam there are but 230 pounds of this element. The magnesium varies in the different types from 1,750 pounds to 20,320 pounds, and the calcium content ranges from 3,270 pounds to 70,780 pounds per acre.

It is important to note that some of the plant-food elements are present in very limited quantities as compared with crop requirements. Some simple computations are of interest in this connection. Assume, for example, that a four-field crop rotation of wheat, corn, oats, and clover yields 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. It will be found that the most prevalent upland soil of McHenry county, the yellow-gray silt loam, does not contain enough total nitrogen in the plowed soil for the production of such yields to supply four rotations. With respect to phosphorus the condition differs only in degree, this soil containing no more of that essential element than would be required for ten crop rotations yielding at the rates suggested above. On the other hand the amount of potassium in the surface layer of this common soil type would be sufficient for more than 25 centuries if only the grain were sold, or for more than 400 years if the total crops should be removed from the land and nothing returned.

These general statements relating to the total quantities of these plant-food materials in the plowed soil of the most prevalent type in the county certainly emphasize the fact that the supplies of some of these necessary elements of fertility are extremely limited when measured by the needs of large crop yields for even one or two generations of people.

THE SUBSURFACE AND SUBSOIL

In Tables 3 and 4 are recorded the amounts of plant food in the subsurface and subsoil of the different types of soil in McHenry county. It should be remembered, however, that these supplies are of little value unless the top soil is kept rich. These tables also show great stores of potassium and only limited amounts of nitrogen and phosphorus, in agreement with the data for the corresponding surface samples.

TABLE 2.—PLANT FOOD IN THE SOILS OF McHENRY COUNTY, ILLINOIS: SURFACE SOIL
Average pounds per acre in 2 million pounds of surface soil (about 0–6⅔ inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone and soil acidity
	(a) Upland Prairie Soils (700, 1000, 1200)								
-26	Brown silt loam	49 570	4 500	1 190	730	35 760	5 670	8 700	In connection with these tabulated data it should be explained that the figures on limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm, and even from field to field. Therefore no attempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, page 29.
-60	Brown sandy loam	38 050	3 380	970	640	30 140	4 990	6 800	
-90	Gravelly loam	64 040	5 820	1 860	1 020	25 700	20 320	27 300	
	(b) Upland Timber Soils (700, 1000, 1200)								
-34	Yellow-gray silt loam	21 280	1 990	750	460	34 160	3 030	6 140	
-35	Yellow silt loam	25 140	1 940	760	240	28 720	7 360	12 020	
-64	Yellow-gray sandy loam	13 890	1 210	580	230	28 970	2 010	4 580	
-65	Yellow sandy loam	28 480	1 980	840	320	30 480	5 420	14 320	
	(c) Terrace Soils (1500)								
-27	Brown silt loam over gravel	60 650	5 210	1 430	890	34 950	6 030	7 920	
-26.4	Brown silt loam on gravel	52 080	4 600	1 290	790	31 190	6 080	8 700	
-25	Black silt loam	130 190	12 740	2 600	1 850	28 650	13 390	66 760	
-66	Brown sandy loam over gravel	33 460	2 850	1 040	590	25 230	3 350	3 270	
-60.4	Brown sandy loam on gravel	34 620	2 830	1 050	610	25 380	1 750	4 870	
-36	Yellow-gray silt loam over gravel	28 400	2 850	1 170	510	36 630	3 230	6 650	
-34.4	Yellow-gray silt loam on gravel	26 460	2 300	840	340	33 900	3 820	4 720	
-67	Yellow-gray sandy loam over gravel	22 160	1 980	760	320	32 800	3 600	6 560	
-64.4	Yellow-gray sandy loam on gravel	20 640	1 700	840	300	29 160	1 960	5 760	
-28	Brown-gray silt loam on tight clay	74 380	7 180	1 420	1 020	35 680	2 860	7 140	
-90	Gravelly loam	61 420	6 000	1 800	1 400	25 840	8 880	60 860	
	(d) Late Swamp and Bottom-Land Soils (1400)								
-50	Black mixed loam	132 380	12 150	2 430	2 070	24 640	8 590	53 740	
-50.2	Black mixed loam on sand	75 460	6 840	1 160	1 240	21 840	2 780	24 260	
-01	Deep peat[1]	235 710	35 990	1 830	5 500	1 820	3 810	26 950	
-02.2	Medium peat on sand[1]	278 560	24 040	1 190	5 030	6 930	3 830	41 520	
-54	Mixed loam	160 900	16 000	3 380	2 680	23 840	10 680	70 780	

[1]Amounts reported are for 1 million pounds of deep peat and medium peat.

TABLE 3.—PLANT FOOD IN THE SOILS OF MCHENRY COUNTY, ILLINOIS: SUBSURFACE SOIL

Average pounds per acre in 4 million pounds of subsurface soil (about $6\frac{2}{3}$–20 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone and soil acidity
	(a) Upland Prairie Soils (700, 1000, 1200)								
-26	Brown silt loam	50 580	4 790	1 850	780	74 380	15 370	17 690	In connection with these tabulated data it should be explained that the figures on limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm, and even from field to field. Therefore no attempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, page 29.
-60	Brown sandy loam	44 040	3 840	1 640	1 080	70 060	16 080	64 600	
	(b) Upland Timber Soils (700, 1000, 1200)								
-34	Yellow-gray silt loam	17 900	1 940	1 610	580	73 460	11 220	15 680	
-35	Yellow silt loam	26 760	2 160	1 400	400	60 680	16 800	41 680	
-64	Yellow-gray sandy loam	17 930	1 600	1 350	350	61 280	8 930	13 200	
-65	Yellow sandy loam	21 280	1 560	1 600	240	62 160	21 240	48 280	
	(c) Terrace Soils (1500)								
-27	Brown silt loam over gravel	52 460	4 970	1 980	960	73 830	8 340	15 200	
-26.4	Brown silt loam on gravel	59 800	5 320	2 230	1 170	65 280	10 730	14 040	
-25	Black silt loam	80 680	7 680	3 140	1 520	68 440	26 960	62 000	
-66	Brown sandy loam over gravel	43 400	4 060	1 660	1 000	49 380	4 080	5 800	
-60.4	Brown sandy loam on gravel	41 880	3 450	1 880	890	48 310	6 120	9 050	
-36	Yellow-gray silt loam over gravel	18 500	2 280	2 300	440	75 260	11 060	11 660	
-34.4	Yellow-gray silt loam on gravel	20 640	2 240	1 640	400	68 880	9 360	13 040	
-67	Yellow-gray sandy loam over gravel	18 960	2 160	1 440	200	72 080	10 600	10 080	
-64.4	Yellow-gray sandy loam on gravel	20 320	1 960	1 520	600	60 160	6 680	8 880	
-28	Brown-gray silt loam on tight clay	31 200	2 840	1 120	1 000	78 200	7 720	13 760	
	(d) Late Swamp and Bottom-Land Soils (1400)								
-50	Black mixed loam	136 700	11 590	4 000	2 250	60 140	15 160	48 120	
-50.2	Black mixed loam on sand	16 400	1 080	840	40	48 760	3 560	9 280	
-01	Deep peat[1]	943 430	68 470	2 230	10 550	2 400	7 720	53 930	
-02.2	Medium peat on sand.[1]	553 360	40 200	1 960	8 540	14 300	4 920	63 020	
-54	Mixed loam	164 720	16 040	5 360	2 840	43 960	19 680	209 480	

[1]Amounts reported are for 2 million pounds of deep peat and medium peat.

TABLE 4.—PLANT FOOD IN THE SOILS OF McHENRY COUNTY, ILLINOIS: SUBSOIL
Average pounds per acre in 6 million pounds of subsoil (about 20-40 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone and soil acidity
	(a) Upland Prairie Soils (700, 1000, 1200)								
-26	Brown silt loam	29 170	3 040	2 530	900	104 000	52 560	86 010	In connection with these tabulated data it should be explained that the figures on limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm, and even from field to field. Therefore no attempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, page 29.
-60	Brown sandy loam	25 680	2 790	2 130	900	118 620	73 380	175 020	
	(b) Upland Timber Soils (700, 1000, 1200)								
-34	Yellow-gray silt loam	15 930	1 930	2 830	720	110 180	24 710	63 930	
-64	Yellow-gray sandy loam	13 760	1 560	2 300	280	97 360	24 640	35 580	
-65	Yellow sandy loam	24 600	1 380	2 700	300	96 060	46 380	208 740	
	(c) Terrace Soils (1500)								
-27	Brown silt loam over gravel	27 590	3 140	2 850	800	103 730	33 560	32 630	
-26.4	Brown silt loam on gravel	29 580	2 900	2 520	500	84 180	20 140	20 700	
-25	Black silt loam	18 720	1 980	3 120	600	103 620	104 160	294 870	
-66	Brown sandy loam over gravel	28 200	2 610	2 220	900	78 300	8 220	19 170	
-60.4	Brown sandy loam on gravel	22 820	2 080	2 340	720	69 740	12 020	39 500	
-36	Yellow-gray silt loam over gravel	15 180	2 190	3 810	270	107 820	19 530	20 610	
-34.4	Yellow-gray silt loam on gravel	15 060	1 620	2 520	240	84 060	18 360	22 800	
-67	Yellow-gray sandy loam over gravel	19 980	2 040	2 640	540	127 800	54 720	139 020	
-64.4	Yellow-gray sandy loam on gravel	16 620	2 160	2 460	540	84 780	12 600	28 440	
-28	Brown-gray silt loam on tight clay	35 880	3 420	1 380	660	125 160	11 640	17 100	
	(d) Late Swamp and Bottom-Land Soils (1400)								
-50	Black mixed loam	55 010	4 460	4 490	2 000	94 880	19 930	105 180	
-50.2	Black mixed loam on sand	10 380	360	1 500	0	74 760	6 060	26 760	
-01	Deep peat[1]	1 395 230	65 880	2 310	19 260	7 590	9 170	70 320	
-02.2	Medium peat on sand	40 560	2 640	1 500	1 380	78 840	47 460	386 160	
-54	Mixed loam	85 560	6 960	3 660	2 100	62 760	44 040	439 260	

[1]Amounts reported are for 3 million pounds of deep peat.

DESCRIPTION OF INDIVIDUAL SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of McHenry county cover an area of 153.05 square miles, or 25.11 percent of the area of the county. They are usually dark in color, owing to their large organic-matter content. The accumulation of organic matter in the prairie soils is due to the growth of prairie grasses that once covered them. The network of roots from these grasses was protected from complete decay by the imperfect aeration resulting from the covering of fine soil material and from the water it contained. On the native prairies the tops of these grasses were usually burned or decayed almost completely, so that the tops added very little organic matter to the soil.

Brown Silt Loam (726, 1026, 1226)

Brown silt loam, covering an area of 120.08 square miles, or 19.7 percent of the total area of the county, is one of the most extensive types in McHenry county. It occupies a considerable part of the less rolling land, some of which needs artificial drainage. The presence of kettle-holes makes complete drainage rather difficult, with the result that many small ponds are found. Small local areas of yellow-gray silt loam, sandy loam, gravelly loam, black mixed loam, and peat, too small to be shown on the map, are included in the type.

The surface soil, 0 to 6⅔ inches, is a brown silt loam, varying from yellowish brown on the more rolling areas to dark brown or black on the more nearly level and poorly drained tracts. In physical composition it varies to some extent but normally contains from 50 to 70 percent of the different grades of silt. In the low areas the proportion of clay is usually higher than on the more rolling parts, where a perceptible amount of sand may occur. The organic-matter content is somewhat variable but averages approximately 4.2 percent, or 42 tons per acre. The content is lower on the more rolling areas and higher on the more level parts. Where considerable erosion has occurred on the steep slopes of moraines, the type is mapped as yellow-gray silt loam although timber may never have grown there.

The natural subsurface is represented by a stratum varying from 6 to 20 inches in thickness. This variation is due to differences in topography and to erosion, the stratum being thinner on the more rolling areas. Less organic matter has accumulated on these areas than on the more level tracts and it disappears more rapidly with depth. In physical composition the subsurface varies in the same manner as the surface, but normally contains a slightly larger amount of clay and a smaller amount of organic matter. The organic-matter content of the stratum sampled (6⅔ to 20 inches) averages about 2.2 percent, varying from 1.8 to 2.8 percent. In color the subsurface varies from dark brown to light yellowish brown, becoming lighter with depth.

The natural subsoil begins at a depth of 12 to 20 inches and extends to an indefinite depth, but for analysis it is sampled to a depth of 40 inches. It varies from a yellow to a drabbish yellow clayey material usually made up of glacial drift. In some of the flat areas, however, where material has washed in from the surrounding parts, the drift is not reached at a depth of 40 inches. In some

places the stratum of glacial gravel beneath the loessial material is very evident and interferes in the collecting of samples.

Treatment.—Altho brown silt loam is fairly well supplied with organic matter, continuous cropping and the removal of practically all the crop residues will gradually reduce the amount until this, with its nitrogen, becomes the limiting factor in crop yields. On many farms or on parts of farms, this condition has already been reached.

In the management of this type, it is essential that manure or crop residues, including legumes, should be returned to the soil in the most practical and advantageous way. No form of organic matter should be burned. In live-stock farming the manure should be applied to the soil as soon as possible after it is produced, in order to avoid loss. Limestone and phosphorus should usually be applied to soil of this type. For results secured in field experiments on brown silt loam, see page 38 of the Supplement.

Brown Sandy Loam (960, 1060)

Brown sandy loam occurs principally in the southern part of the county and covers an area of 28.24 square miles, or 4.63 percent of the total area of the county. The sand of the type is derived very largely from glacial material. The type varies in topography from almost flat to decidedly rolling.

The surface soil, 0 to 6⅔ inches, consists of a brown sandy loam varying in color from a light or yellowish brown to a dark brown or even to a black. The sand content varies, being most abundant in the small patches that have been produced largely by the action of the wind. The organic-matter content is about 3 percent, or 30 tons per acre.

The subsurface, 6⅔ to 18 or 20 inches, consists of a brown to a yellowish brown sandy loam varying in the same manner as the surface soil. The organic-matter content is about 1.9 percent, or 38 tons per acre.

The subsoil is variable, in some places being made up of boulder clay while in others it is a yellowish sand, a clayey sand, or a sandy clay.

Treatment.—In general the type is sufficiently rolling for good drainage. It requires for its improvement the large use of organic matter, applied both as manure and as crop residues. This soil, being loose and better aerated than brown silt loam, suffers greater loss of organic matter by oxidation; hence greater difficulty is experienced in maintaining the necessary supply. Crop residues, legume crops, and manure must constitute the chief materials by which the organic matter is maintained. Ground limestone should usually be applied at the rate of about 2 or 3 tons per acre. These applications should be made frequently enough to keep a supply in the soil, but need not be made oftener than every four or five years. Sometimes the subsurface is well stocked with limestone in which case the supply will be easy to maintain.

Gravelly Loam (790, 1090)

Gravelly loam usually occurs in small areas and is fairly well distributed over the county, altho none is found in the Iowan glaciation. The type covers

an area of 3,027 acres. It is of very little importance from an agricultural standpoint, being adapted only for a low grade of pasture land.

(b) UPLAND TIMBER SOILS

The upland timber soils are deficient in organic matter owing to the fact that in forests the vegetable material from trees accumulates upon the surface and is either burned or suffers almost complete decay. Grasses, which furnish large amounts of humus-forming roots, do not grow to any extent. Moreover, the organic matter that had accumulated before the timber began growing is removed thru various decomposition processes, with the result that in these soils generally the nitrogen and organic-matter contents have become too low for the best growth of farm crops. The total area of upland timber soils in the county is 179.88 square miles, or 29.52 percent of the area of the county.

Yellow-Gray Silt Loam (734, 1034, 1234)

Yellow-gray silt loam is the most extensive soil type in McHenry county, covering an area of 130.04 square miles, or 21.34 percent of the total area of the county. While this type is confined chiefly to the more rolling parts of the moraines, it is also found irregularly distributed over other parts of the county.

The surface soil, 0 to 6⅔ inches, is a gray or yellowish gray silt loam, incoherent and mealy, but not granular. It varies greatly in physical composition, owing to the fact that in many places the thin covering of loess has been removed by erosion and a variable drift exposed. There are many local areas of sand or gravelly loam, but they are too small to be shown on the map. Likewise, there are many small areas of black mixed loam or black silt loam too small to be indicated on the map, that are found in kettle-hole depressions. The amount of organic matter in the surface stratum varies from 1.3 to 2.1 percent, with an average of about 1.8 percent, or 18 tons per acre. In some places erosion has reduced the content of organic matter much below the point of productiveness, and many small areas are decidedly yellow in color. On many of the steeper slopes much gravel and even small boulders are found.

The natural subsurface varies from 3 to 10 inches in thickness, being thinner on the more rolling areas. In color it is gray, grayish yellow, or yellow. It is somewhat pulverulent, but becomes more coherent and plastic with depth. The organic-matter content is about .8 percent, or 16 tons per acre in four million pounds of soil.

The subsoil is usually a yellow to a grayish yellow boulder clay. On the more level areas, however, the boulder clay may not be reached within 40 inches of the surface. The deeper subsoil frequently contains large amounts of limestone, as shown by the brisk effervescence when the hydrochloric acid test is applied.

Treatment.—In the management of yellow-gray silt loam, one of the essential points is the maintenance or increase of organic matter. This is even more necessary with this type than with brown silt loam, because this soil is naturally much more deficient in that constituent. The organic matter tends to prevent "running together," and on some of the more rolling areas lessens the washing. It gives better tilth to the soil under all conditions. As it decays, it supplies nitrogen and tends to liberate other plant food, as explained in the Appendix.

For adding organic matter to the soil the extensive use of the clovers, alfalfa, or other legumes is advised. These should be returned either directly to the soil along with crop residues, or in the manure produced in their consumption.

Because of the fact that in this type of soil in McHenry county carbonates are usually found in abundance in the subsoil and are sometimes present in the subsurface, it is difficult to prescribe a definite recommendation for the application of limestone that will apply to all locations. However, for the thrifty growth of such legumes as sweet clover and alfalfa limestone should be present in the surface soil in order to give the young plants a vigorous start. Therefore a moderate application of limestone, say 2 tons per acre, ought to prove profitable on all land of this type, and in some situations perhaps more than this amount could be applied to advantage, depending upon the depth to the naturally existing limestone.

Ultimately, for the best results in crop production the phosphorus content will need to be increased.

For results from practical field experiments on yellow-gray silt loam, see page 46 of the Supplement.

Yellow Silt Loam (735, 1035)

Yellow silt loam occurs principally along the Fox river in Town 43 North, Range 8 East, and in the northeast part of Town 44 North, Range 7 East. The type covers 3,149 acres, or less than one percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a yellow or yellowish gray silt loam, which usually contains some sand or gravel. This stratum is frequently formed from glacial drift, the loess having been removed by erosion. Owing to its derivation it varies a great deal in physical composition. The organic-matter content is about 2.3 percent, or 23 tons per acre.

The natural subsurface varies from 3 to 10 inches in thickness and is composed chiefly of a yellow or yellowish gray silt loam, but may vary from this to boulder clay and even to a very gravelly form of boulder clay. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about .9 percent.

The subsoil is made up of boulder clay, with about .4 percent of organic matter.

Treatment.—One of the best uses to which this type can be put is permanent pasture. As a rule, it cannot be satisfactorily cropped in ordinary rotations but it may be used very successfully for long rotations with pasture or meadow much of the time. Where limestone is naturally lacking in the upper portion of the soil, this material may well be used for the legumes in the rotation, or even as a top dressing to encourage their growth in pastures. Where this type has been long cultivated and thus exposed to surface washing, it is particularly deficient in nitrogen. Indeed, on such land the low supply of nitrogen is the factor that first menaces the growth of grain crops. Nitrogen is to be obtained from the air thru the growth of leguminous crops.

Yellow-Gray Sandy Loam (764, 1064)

Yellow-gray sandy loam occurs in many irregular areas all over the county. The total area covered by this type is 43.82 square miles, or 7.19 percent of

the area of the county. Its topography is about the same as that of the yellow-gray silt loam, and it occurs on morainal areas somewhat similar to that type.

The surface soil, 0 to 6⅔ inches, is a gray or yellowish gray sandy loam, varying rather widely in its physical composition. In some localities it contains a considerable percentage of gravel, sufficient in many cases to form a gravelly loam, but the areas are too small to be shown on the map. The organic-matter content is approximately 1.2 percent, or 12 tons per acre.

The natural subsurface is represented by a stratum from 4 to 10 inches in thickness. It varies in physical composition the same as the surface, except that it contains more gravel. It is frequently formed from the glacial drift. The stratum sampled (6⅔ to 20 inches) contains about .8 percent of organic matter.

The subsoil is made up of glacial drift and contains about .4 percent of organic matter. The surface and subsurface are usually acid, altho the subsoil sometimes contains a considerable amount of limestone.

Treatment.—Where clover continues to fail on this type, applications of 2 tons of ground limestone can well be made for the purpose of increasing the growth of legumes. The content of organic matter and of nitrogen must be largely increased, since this type is one of the lowest in organic matter found in the county. The phosphorus content is very low and should therefore be built up in order to obtain the best results. Sweet clover is an excellent crop to grow on this type because of the large amount of organic matter that it supplies.

Yellow Sandy Loam (1065)

Yellow sandy loam occurs in the very rolling and sandy area of the county. It occupies 704 acres.

The surface soil, 0 to 6⅔ inches, is in the main a yellow sandy loam altho it varies considerably in physical composition, in places containing some gravel. The type contains a larger amount of organic matter than does the yellow-gray sandy loam because of the fact that it has never been under cultivation. The organic-matter content is 2.4 percent, or twice the amount present in the preceding type.

The subsurface also varies in physical composition, being rather gravelly in some places.

The subsoil corresponds in physical composition to the surface and subsurface.

Treatment.—This type is adapted only to pasture, and legumes should be grown on it. Sweet clover is probably one of the best plants for the purpose. Limestone is likely to be beneficial.

(c) TERRACE SOILS

Terrace soils usually occur along streams. They were formed at a time when the streams, owing to melting glacier ice, were much larger than they are at present, and carried large amounts of coarse material, such as sand and gravel. Upon any decrease in their velocity, these overloaded streams deposited debris along their courses. This resulted in the partial filling of the valley and the formation of what are now the terraces, bench lands, or second bottom lands.

Finer material later deposited over this sand and gravel forms the present soil. When the streams became reduced to their normal size after the glacier had melted, they began cutting down thru this deposit, and the beds of the streams are now so low that the terraces, or benches, do not overflow.

Several gravel outwash plains occur which were formed by the sand and gravel that was deposited when water from the melting ice spread over large level areas. These plains were later covered by the finer material which forms the present soil.

Brown Silt Loam over Gravel (1527)

Brown silt loam over gravel occurs in four large areas in the county, one near Hebron, one near Harvard, one north of Franklinville, and the other just west of Rush creek. The type covers 45.93 square miles, or 7.54 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, varies from a brown to a very dark brown silt loam which frequently contains some sand, altho not enough to cause it to be classified as a sandy loam. While the topography is usually flat, some slight undulations occur which were probably produced by the channels of the flooded streams. The surface soil contains about 5 percent of organic matter, or 50 tons per acre. It varies from 4 to 6.5 percent.

The natural subsurface stratum varies from 7 to 16 inches in thickness. The organic-matter content of the stratum as sampled (6⅔ to 20 inches) is about 2.3 percent, or 46 tons per acre. In physical composition it is about the same as the surface.

The subsoil is a yellow to a mottled yellow silt loam with some gravel appearing in the deeper subsoil. The depth to gravel, however, varies from 36 to 54 inches or more.

Treatment.—All strata are pervious to water, so that drainage is very good, provided a sufficient outlet is obtained. The gravel is so far from the surface that crops do well even in years of some drouth. This is one of the best of the terrace types. In the improvement of this type, limestone, phosphorus, and organic matter should be provided as recommended for the brown silt loam of the upland (see page 11).

Brown Silt Loam on Gravel (1526.4)

Brown silt loam on gravel represents a type in which the fine soil material is less than 30 inches in thickness, or in which the gravel is within 30 inches of the surface. The principal areas are found in the broad valleys of Rush creek and the north branch of the Kishwaukee. The total area is 4,358 acres, or 1.12 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a brown silt loam containing some sand. Organic matter is present to the amount of about 4.8 percent, or 48 tons per acre.

The natural subsurface stratum varies from 8 to 12 inches in thickness, and is a brown to light yellowish brown silt loam containing gravel which in some cases amounts to as much as 5 percent. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 2.6 percent, or 52 tons in four million pounds of soil.

The subsoil is about the same as the subsurface until gravel is reached. The gravel consists of a mixture of fine gravel and sand with some of the finer soil constituents.

Treatment.—This soil type is well drained, but because of the nearness of gravel to the surface it does not resist drouth well. For this reason early maturing crops are desirable. In the management of the type care must be taken to maintain the supply of organic matter, since this constituent is so important in the conservation of moisture. An application of 2 or 3 tons per acre of limestone is recommended in order that clover or alfalfa may be grown.

Black Silt Loam (1525)

Black silt loam occurs in the lower and more poorly drained parts of the terrace. Either the gravel is so deep or the outlet is so poor that drainage does not take place readily. The type covers an area of 1,069 acres.

The surface soil, 0 to 6⅔ inches, is a black silt loam becoming in some cases so heavy as to form a black clayey silt loam. It contains about 10.5 percent of organic matter, or 105 tons per acre.

The natural subsurface soil is a black clayey silt loam and extends to a depth of 18 to 20 inches. The stratum sampled (6⅔ to 20 inches) contains approximately 2.8 percent of organic matter.

The subsoil is represented by a clayey stratum varying in color from a pale yellow to a drabbish yellow. It contains about .5 percent of organic matter.

Treatment.—All strata are pervious to water so that drainage is effected very readily when proper tiling is done. In the management of this type about the only consideration at present is the maintenance of good physical condition by means of active organic matter. Usually a good supply of phosphorus and limestone is present.

Brown Sandy Loam over Gravel (1566)

Brown sandy loam over gravel is found principally in the south third of the county. It covers an area of 8.41 square miles or 5,382 acres. The topography is flat to slightly undulating.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam with about 2.9 percent of organic matter, or 29 tons per acre.

The subsurface is a brown sandy loam containing about 1.9 percent of organic matter. In physical composition it is practically the same as the surface soil, but it becomes yellow at about 16 to 18 inches.

The subsoil is a yellow sandy silt which in some cases becomes gravelly at 36 inches.

Treatment.—The very low nitrogen content, which is characteristic of a sandy soil, calls for the liberal use of legume crops; and the chemical analysis indicates the need of limestone in order to insure a thrifty growth of the legumes. An application of about 2 tons per acre of ground limestone is suggested. The phosphorus content is also low and doubtless as times goes on, under a system that produces larger crops, phosphorus will become a limiting element that will need to be replenished.

Brown Sandy Loam on Gravel (1560.4)

Brown sandy loam on gravel occurs very largely in the southern part of the county in the vicinity of Marengo. Another large area occurs south of Crystal Lake. The type covers an area of 31.31 square miles, or 5.14 percent of the area of the county. The topography is flat.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam varying in sand content and containing from 2 to 3 percent of gravel. The organic-matter content averages 2.5 percent.

The subsurface stratum contains about 1.7 percent of organic matter and a noticeable amount of gravel.

The gravel subsoil begins at a depth of 16 to 28 inches and consists of a mixture of coarse sand and fine gravel. Comparatively small amounts of the finer soil constituents are present in this gravel. The nearness of gravel to the surface reduces the moisture-holding capacity of this type, with the result that crops may suffer from drouth.

Treatment.—The type is sometimes acid in the upper strata but occasionally the subsoil contains a considerable amount of limestone. In the management of this soil the same recommendations apply as those given in the discussion of the preceding type.

Yellow-Gray Silt Loam over Gravel (1536)

Yellow-gray silt loam over gravel is found in various parts of the county but more particularly along the lower Fox river, in the Iowan glaciation in the northwest part of the county, and in Towns 45 and 46 North, Range 7 East. The total area is 13.85 square miles.

The surface soil, 0 to 6⅔ inches, is a brownish yellow or grayish yellow silt loam, verging toward yellow sandy loam in some localities. The organic-matter content averages 2.4 percent, or 24 tons per acre.

The natural subsurface is a stratum of a yellowish or grayish yellow color. It varies from 8 to 10 inches in thickness. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about .8 percent.

The subsoil is a yellow silt to clayey silt.

Treatment.—The nitrogen in this soil is very low, and methods looking toward its replenishment should be adopted at once. Applications of limestone amounting to 2 or 3 tons per acre should be made, and this material will probably need to be replenished every four or five years in order to encourage the growth of legumes. The organic-matter content should be maintained by turning under crop residues and all forms of available organic material. The phosphorus supply also is insufficient and in the course of time, if not immediately, this element should be applied.

Yellow-Gray Silt Loam on Gravel (1534.4)

Yellow-gray silt loam on gravel is found widely distributed thruout the county, but covers a total area of only 5.88 square miles.

The surface soil, 0 to 6⅔ inches, is a brownish yellow or yellowish gray silt loam containing about 2.3 percent of organic matter.

The subsurface is represented by a stratum from 7 to 10 inches in thickness. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about .9 percent.

The subsoil is a yellowish clayey silt which in some cases passes into gravel at 30 to 38 inches.

Treatment. This soil is similar in composition to that of the preceding type. It is low in organic matter, nitrogen, and phosphorus, and limestone is absent. In order to improve it, therefore, an application of 2 or 3 tons of limestone per acre should be made, and legumes should be grown either to be turned back into the soil directly or to be fed to stock and the manure applied. The phosphorus content should be increased by applying from ½ to 1 ton per acre of raw rock phosphate in a four- or five-year rotation.

Yellow-Gray Sandy Loam over Gravel (1567)

Yellow-gray sandy loam over gravel is found principally along the Fox river. It covers an area of 877 acres.

The surface soil, 0 to 6⅔ inches, is a gray to grayish yellow sandy loam with about 1.9 percent of organic matter, or 19 tons per acre.

The natural subsurface consists of a yellow sandy loam varying from 6 to 10 inches in thickness. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is approximately .8 percent.

The subsoil varies from a yellow sandy silt to a yellow sand. The former is much more common than the latter.

Treatment. The type is rather low in several elements of plant food. Legumes should be grown in order to increase the nitrogen, as the chemical analysis shows the total amount of this element to be less than 2,000 pounds in the plowed soil. The subsoil usually contains a considerable amount of limestone; but since this material is lacking in the surface and subsurface, an application of about 2 tons per acre is recommended. The phosphorus supply is likewise very meagre, and before this becomes a limiting element it should be increased by applications of a half ton or more of raw rock phosphate to the acre every four or five years.

Yellow-Gray Sandy Loam on Gravel (1564.4)

Yellow-gray sandy loam on gravel occurs in various parts of the county, but not in any large areas. It is always mixed more or less with other types. The total area amounts to 2,694 acres.

The surface soil, 0 to 6⅔ inches, is a yellow or grayish yellow sandy loam containing about 1.8 percent of organic matter, or 18 tons per acre.

The natural subsurface soil is represented by a stratum 6 to 10 inches in thickness. The stratum sampled (6⅔ to 20 inches) contains about .9 percent of organic matter.

The subsoil is a yellowish sandy silt which passes into gravel at a depth of 18 to 26 inches.

Treatment.—This soil, as is characteristic of a sandy loam, is very low in nitrogen (less than 2,000 pounds per acre being present in the plowed soil) and organic matter. The stock of phosphorus is likewise decidedly low. In the management of this soil, therefore, legumes should be grown and all available

manure should be applied. Analysis shows no limestone above the subsoil; therefore crushed limestone should be applied at the rate of about 2 tons per acre. Phosphorus may be supplied in the form of finely ground raw rock phosphate at the rate of ½ to 1 ton per acre.

Brown-Gray Silt Loam on Tight Clay (1528)

Only a very small area of brown-gray silt loam on tight clay, 19 acres in extent, occurs in the county.

The surface soil, 0 to 6⅔ inches, is a brown silt loam containing about 6.4 percent of organic matter.

The subsurface is a gray silt loam containing approximately 1.3 percent of organic matter.

The subsoil consists of a tight clay, rather impervious.

Treatment.—According to the analysis, limestone is absent. Therefore this material should be applied at the rate of about 2 tons per acre. The growing of sweet clover is recommended. This may serve to some extent to break up the clay of the subsoil.

Gravelly Loam (1590)

Gravelly loam does not form an important type agriculturally, covering as it does only one square mile.

The surface soil contains about 5.3 percent of organic matter. The type is of value only for pasture.

(d) LATE SWAMP AND BOTTOM-LAND SOILS

Black Mixed Loam (1450)

Black mixed loam is the most common of the swamp types, and is distributed all over the county. The areas vary in size from those that are several square miles in extent to numberless areas too small to map. The type covers an area of 104.45 square miles, or 17.14 percent of the total area of the county.

The surface soil, 0 to 6⅔ inches, is a black soil varying from a peat on one hand to a clay loam or a black sandy loam on the other. These different types are so small in extent that it is practically impossible to show them on the map. Hence the entire area is mapped as the black mixed loam. The plowed soil contains about 11.4 percent of organic matter, or 114 tons per acre.

The natural subsurface is represented by a stratum 8 to 12 inches in thickness. The stratum sampled (6⅔ to 20 inches) contains about 5.9 percent of organic matter, or 118 tons per acre.

The subsoil is a yellowish drab or drab silty clay or clayey silt which contains about 1.6 percent of organic matter.

Treatment.—All strata are pervious to water, so that artificial drainage may result in transforming this land into very productive soil. It is well supplied with phosphorus and nitrogen. Limestone is often abundant in all strata but sometimes it may be totally absent. In such exceptional cases the artificial application of this material should be made. This land is used principally for pasture because of the fact that it has not yet been sufficiently drained for cropping.

Black Mixed Loam on Sand (1450.2)

Black mixed loam on sand occurs in the vicinity of Marengo and extends into Boone county to the west. It covers an area of 6.48 square miles.

The surface soil, 0 to 6⅔ inches, varies from a loam to a sandy loam. It contains about 6.5 percent of organic matter.

The subsurface is a black to grayish sand with about .7 percent of organic matter.

The subsoil is a gray or yellow sand.

Treatment.—Provision for drainage, which is the first requirement of this land, has already been made in the principal tract of this type. Cropping, however, has been pretty largely attended by failure. This kind of soil is not constituted to endure drouth, and successful cropping will therefore depend much upon the time of maturity of crops grown, the distribution of rainfall, and the height of the water table. Early maturing crops, such as winter wheat and rye, provided conditions at time of seeding in the autumn are sufficiently favorable to insure germination, are much more likely to succeed than a crop like corn.

A definite prescription for the application of fertilizing materials is scarcely warrantable at this time because this type of soil is so peculiar that reliable information must be based very largely upon actual experience.

Deep Peat (1401)

Deep peat is distributed thruout the county and covers 36.74 square miles, or 6.03 percent of the total area of the county.

The surface soil, 0 to 6⅔ inches, is a black peat containing about 75 percent of organic matter, or 375 tons per acre.

The subsurface soil contains about 81 percent of organic matter.

The subsoil contains about 80 percent of organic matter.

Treatment.—Drainage is the first requirement of this type. This in many cases is rather difficult to secure because tiles cannot be laid to good advantage in peat on account of irregular settling and the consequent displacement of the line. This difficulty may be partly overcome by placing the tiles upon boards laid in the bottom of the ditch, altho such a system cannot be regarded as permanent.

Where thoro drainage can be provided, either by the above method or by open ditches, very marked improvement can be made in the productive power of peat by the liberal use of potassium, which is by far the most deficient element. Farm manure and crop residues contain sufficient potassium to make their use very effective on deep peat soil; and with commercial potash salts at prohibitive prices, farm manure, corn stalks, straw, etc., must be utilized for the improvement of such soils.

The chemical analysis shows that limestone is not always present in the deep peat of McHenry county. When the simple tests described in the Appendix, page 29, indicate the absence of limestone, then this material should be applied at the rate of about 2 tons per acre.

For an account of field experiments on deep peat the reader is referred to page 49 of the Supplement.

PLATE 9.—HUMMOCKS ON "BOG" LAND CHARACTERISTIC OF PEAT AND CERTAIN OTHER SWAMPY SOILS AFTER PASTURING

Medium Peat on Sand (1402.2)

Medium peat on sand occurs in low swampy places similar to those occupied by deep peat, but the conditions for the formation of this type have not been so favorable as for deep peat, and as a consequence the peaty material is less than 30 inches thick. The type covers 499 acres.

The surface soil, 0 to 6⅔ inches, contains about 48 percent of organic matter.

The subsurface is of about the same general character as the surface stratum.

The subsoil consists largely of sand, with only 1.2 percent of organic matter.

Treatment.—The type needs drainage and the application of potassium.

Mixed Loam (1454)

Mixed loam occurs as bottom land in different parts of the county, but usually in small areas. There are 1,722 acres of this type in the county.

The surface soil, 0 to 6⅔ inches, contains about 13.9 percent of organic matter and consists of a black mixed loam, the variability of which is produced by depositions during overflow.

The subsurface contains about 7.1 percent of organic matter.

The subsoil contains about 2.5 percent of organic matter.

The type is rich in nitrogen and phosphorus and in the area sampled has an abundance of limestone.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to intelligently interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification here used.

The unit in the soil survey is the soil type, and each type possesses more or less definite characteristics. The line of separation between adjoining types is usually distinct, altho sometimes one type grades into another so gradually that it is very difficult to draw the line between them. In such exceptional cases, some slight variation in the location of soil-type boundaries is unavoidable.

In establishing soil types several factors must be taken into account. These are: (1) the geological origin of the soil, whether residual, cumulose, glacial, eolial, alluvial, or colluvial; (2) the topography, or lay of the land; (3) the native vegetation, as forest or prairie grasses; (4) the depth and the character of the surface, the subsurface, and the subsoil, as to the percentages of gravel, sand, silt, clay, and organic matter which they contain, their porosity, granulation, friability, plasticity, color, etc.; (5) the natural drainage; (6) the agricultural value, based upon its natural productiveness; (7) the ultimate chemical composition and reaction.

Great Soil Areas in Illinois.—On the basis of the first of the above mentioned factors, namely, the geological origin, the state of Illinois has been divided into sixteen great soil areas with respect to their geological formation. The names of these areas are given in the following list along with their corresponding index numbers, the use of which is explained below. For the location of these geological areas, the reader is referred to the general map published in Bulletins 123 and 193.

100 *Unglaciated,* comprizing three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciation
300 *Lower Illinoisan glaciation,* covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river bottom and swamp lands,* found in the older or Illinoisan glaciation
1400 *Late river bottom and swamp lands,* those of the Wisconsin and Iowan glaciations
1500 *Terraces,* formed by overloaded streams draining from the glaciers and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago or the enlarged Lake Michigan

Mechanical Composition of Soils.—The mechanical composition, or the texture, is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents:

Organic matter: undecomposed and partially decayed vegetable material

Inorganic matter: clay, silt, fine sand, sand, gravel, stones.

Classes of Soils.—Based upon the relative proportion of the various constituents mentioned above, soils may be grouped into a number of well recognized classes. Following is a list of these classes, arranged according to their index numbers, the use of which is explained below.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

Naming and Numbering Soil Types.—The naming of soil types has been the subject of much discussion, and practice varies considerably in this matter. In this soil survey of Illinois a system of classification and naming has been adopted which is based upon the various considerations presented in the preceding paragraphs.

After texture, one of the most striking characteristics of a soil is the color. Therefore, in the naming of soils in Illinois, a combination of color and texture, together with other descriptive terms when necessary, has been adopted so that the name in itself carries a definite description of a given soil type; as for example, "gray silt loam on tight clay," or "brown silt loam over gravel." The use of the prepositions *on* and *over* serves to indicate the presence of certain substrata. When the surface soil is underlain with material such as sand, gravel, or rock, the word *over* is used if this material lies at a depth greater than 30 inches; if it is less than 30 inches, the word *on* is used.

For further identification of soil types a system of numbering, resembling somewhat the Dewey library system, has been adopted whereby each soil type is assigned a certain number. This number indicates at once the geological origin of the soil as well as its physical description. The digits of the order of hundreds represent the geological area where the soil is found, beginning at 100 with the unglaciated, and following in series in the order of the enumeration presented in the paragraph above headed *Great Soil Areas In Illinois.* The digits of the orders of units and tens represent the various kinds of soil such as are enumerated above in the list of soil classes. A modification of a soil type called a *phase* is designated in this system by a figure placed at the right of the decimal point. To illustrate the working of this numbering system, suppose a soil type bears the number 726.5. The number 7 indicates that this soil occurs in the Iowan glaciation, the 26 that it is a brown silt loam, and the .5 that rock is found less than 30 inches below the surface. These numbers are especially useful in designating small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and a description of the area covered, will be found in the respective county soil reports.

SOIL SURVEY METHODS

Mapping the Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. In order that the survey be thoroly truthworthy it is necessary that careful, well-trained men be employed to do the mapping. The work is prosecuted to the best advantage by working in parties of from two to four. Only such men are placed in charge of these parties as are thoroly experienced in the work and have shown themselves to be especially well qualified in training and ability.

The men must be able to keep their location exactly and to recognize the different soil types, with their principal variations and limits, and they must show these upon the maps correctly. A definite system is employed in checking up this work. As an illustration, one man will survey and map a strip 80 rods or 160 rods wide and any convenient length, while his associate will work independently on another strip adjoining this area, and if the work is correctly done the soil-type boundaries will match up on the line between the two strips.

An accurate base map for field use is absolutely necessary for soil mapping. The base maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as a basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil-type boundaries, together with the streams, roads, railroads, canals, and town sites are placed in their proper locations upon the map while the mapper is on the area. Each section, or square mile, is divided into 40-acre plots on the map, and the surveyor must inspect every ten acres and determine the type or types of soil composing it. The different types are indicated on the map by different colors, pencils for this purpose being carried in the field.

A small auger 40 inches long forms for each man an invaluable tool with which he can quickly secure samples of the different strata for inspection. An extension for making the auger 80 inches long is taken by each party, so that any peculiarity of the deeper subsoil layers may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by an odometer attached to the axle of the vehicle or by some other measuring device, while distances in the field away from the roads are determined by pacing, an art in which the men become expert by practice. The soil boundaries can thus be located with as high a degree of accuracy as can be indicated by pencil on the scale of one inch to the mile.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. For this purpose usually three strata are sampled; namely, the surface (0 to 6⅔ inches), the subsurface (6⅔ to 20 inches), and the subsoil (20 to 40 inches). These strata correspond approximately, in the common kinds of soil, to 2,000,000 pounds of dry soil per acre in the surface layer, and to two times and three times this quantity in the subsurface and the subsoil, respectively.

By this system of sampling we have represented separately three zones for plant feeding. The surface layer includes at least as much soil as is ordinarily turned with the plow. This is the part with which the farm manure, limestone, phosphate, or other fertilizer applied in soil improvement is incorporated, and which must be depended upon in large part to furnish the necessary plant food for the production of crops. Even a rich subsoil has little or no value if it lies beneath a worn-out surface, but if the fertility of the surface soil is maintained at a high point, then the strong, vigorous plants will have power to secure more plant food from the subsurface and subsoil.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. Even tho plowed alike and at the same time, prepared the same way, planted the same day with the same kind of seed, and cultivated alike, watered by the same rains and warmed by the same sun, nevertheless the best acre may produce twice as large a crop as the poorest acre on the same farm, if not, indeed, in the same field; and the fact should be repeated and emphasized that with the normal rainfall of Illinois the productive power of the land depends primarily upon the stock of plant food contained in the soil and upon the rate at which it is liberated, just as the success of the merchant depends primarily upon his stock of goods and the rapidity of sales. In both cases the stock of any commodity must be increased or renewed whenever the supply of such commodity becomes so depleted as to limit the success of the business, whether on the farm or in the store.

CROP REQUIREMENTS

Ten different elements of plant food are essential for the growth and formation of every plant. These elements are: *carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, magnesium, calcium, and iron;* and they are represented by the chemical symbols: C, O, H, N, P, S, K, Mg, Ca, and Fe. Some seasons in central Illinois are sufficiently favorable to allow the production of at least 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. When such crops are not produced under favorable seasonal conditions, the failure is due to unfavorable soil condition, which may

Table A.—Plant Food in Wheat, Corn, Oats, and Clover

Produce: Kind	Produce: Amount	Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain......	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat, straw.....	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain.......	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover.......	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs........	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain.......	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw........	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed.......	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay.......	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00

result from poor drainage, poor physical condition, or an actual deficiency of plant food.

Table A shows the plant-food requirements of some of our most common field crops with respect to the seven elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of any element removed from an acre of land by a crop of a given yield can easily be computed.

It needs no argument to show that the continuous removal of such quantities of plant food without provision for their replacement must result sooner or later in soil depletion.

PLANT-FOOD SUPPLY

Of the ten elements of plant food, three *(carbon, oxygen,* and *hydrogen)* are secured from air and water, and seven from the soil. *Nitrogen,* one of these seven elements obtained from the soil by all plants, may also be secured from the air by one class of plants (legumes), in case the amount liberated from the soil is insufficient; but even these plants (which include only the clovers, peas, beans, and vetches among our common agricultural plants) are dependent upon the soil for the other six elements *(phosphorus, potassium, magnesium, calcium, iron, and sulfur)*, and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

TABLE B.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	19
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[1]	80	8	28
Dried blood	280	...	...
Sodium nitrate	310	...	...
Ammonium sulfate	400	...	...
Raw bone meal	80	180	...
Steamed bone meal	20	250	...
Raw rock phosphate	...	250	...
Acid phosphate	...	125	...
Potassium chlorid	...	...	850
Potassium sulfate	...	...	850
Kainit	...	...	200
Wood ashes[2]	...	10	100

[1]Young second year's growth ready to plow under as green manure.
[2]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

The vast difference with respect to the supply of these essential plant food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to nearly 33,000 pounds. In like manner the phosphorus content varies from about 420 pounds to 4,900 pounds, the potassium ranges from 1,530 pounds to about 58,000 pounds. Similar variations are found in all of the other essential plant food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table B is presented for the purpose of furnishing information regarding the quantity of plant food contained in some of the materials most commonly used as sources of plant-food supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of fertility actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are limestone and decaying organic matter. Tillage also has a considerable effect in this connection.

Effect of Limestone.—Limestone corrects the acidity of the soil and thus encourages the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the insoluble and unavailable organic nitrogen into soluble and available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium, and also to dissolve the insoluble phosphate and limestone which may be applied in low-priced forms. Thus, in the conversion of sufficient organic nirogen into nitrate nitrogen for a 100-bushel crop of corn, the nitrous acid formed is alone sufficient to convert seven times as much insoluble tricalcium phosphate into soluble monocalcium phosphate as would be required to supply the phosphorus for the same crop.

Effect of Organic Matter.—Organic matter may be supplied by animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter, and by plant manures, including green-manure crops and cover crops plowed under and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant food than the 20 tons of old, inactive organic matter. The history of the individual

farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated more or less definitely by the *ratio of carbon to nitrogen.* As an average, the fresh organic matter incorporated with soils contains about twenty times as much carbon as nitrogen, but the carbohydrates ferment and decompose much more rapidly than the nitrogenous matter; and the old resistant organic residues, such as are found in normal subsoils, commonly contain only five or six times as much carbon as nitrogen. Soils of normal physical composition, such as loam, clay loam, silt loam, and fine sandy loam, when in good productive condition, contain about twelve to fourteen times as much carbon as nitrogen in the surface soil; while in old, worn soils that are greatly in need of fresh, active, organic manures, the ratio is narrower, sometimes falling below ten of carbon to one or nitrogen. Except in newly made alluvial soils, the ratio is usually narrower in the subsurface and subsoil than in the surface stratum. Soils of cut-over or burnt-over timber lands sometimes contain so much partially decayed wood or charcoal as to destroy the value of the nitrogen-carbon ratio for the purpose indicated.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing soluble phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant food by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant food is concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes: Limestone provides the plant food calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much

more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by preventing the growth of certain fungus diseases, such as corn root rot. Experience indicates that it modifies directly the physical structure of some soils, frequently to their great improvement.

Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands. Remarkable success has been experienced with limestone used in conjunction with sweet clover in the reclamation of abandoned hill land which had been ruined thru erosion.

Amounts to Apply.—If the soil is acid, at least 2 tons per acre of ground limestone should be applied as an initial treatment. Continue to apply limestone from time to time according to the requirement of the soil as indicated by the tests described below, or until the most favorable conditions are established for the growth of legumes, using preferably at times magnesian limestone ($CaCO_3MgCO_3$), which contains both calcium and magnesium and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone ($CaCO_3$). On strongly acid soils, or on land being prepared for alfalfa, 4 or 5 tons per acre of ground limestone may well be used for the first application.

How to Ascertain the Need for Limestone.—The need of a soil for limestone may be ascertained by applying one of the following tests for soil acidity. Along with the acidity test, a test for the presence of carbonates should be made. It should be understood that a positive test for carbonates does not guarantee the absence of acid; for it may happen, especially when the soil is near the neutral point, that positive tests for both acidity and carbonates are obtained. This condition is explained by the assumption that solid particles of calcium or magnesium carbonates form centers of alkalinity within a soil that is generally acid. Because of this fact any test made of a given soil ought to be repeated if it is to be thoroly reliable. It is also desirable to test samples from different depths. Following are the directions for making these tests:

The Litmus Paper Test for Acidity. Make a ball of fresh moist soil, break it in two, insert a piece of blue litmus paper, and press the soil firmly together again. After a few minutes examine the paper. If it has turned pink or red, soil acidity is indicated. The intensity of the color and the rapidity with which it develops indicates to some extent the amount of acidity. Needless to say the reliability of the test depends upon the quality of litmus paper used.

The Potassium Thiocyanate Test for Acidity. A more recently discovered test for soil acidity which promises to be more satisfactory than the litmus test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol (not denatured). When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. The conditions for a prompt reaction require a temperature that is comfortably warm.

The Hydrochloric Acid Test for Carbonates. Make a shallow cup of a ball of soil and pour into it a few drops of concentrated hydrochloric acid. If carbonates are present they are decomposed with the liberation of carbon dioxid, which appears as gas bubbles, producing foaming or effervescence. With much carbonate present the action is lively, but with mere traces of it the bubbles are given off slowly. If no carbonate, or very little, is indicated by the test, then it is advisable to apply limestone.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen costs from four to

five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for agricultural uses. *These are the chemical and the biological fixation of the atmospheric nitrogen.* Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of those legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for feed and seed as well as for nitrate production, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen, the possibilities of which now represent numerous compounds, will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes.

For easy figuring it may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy requires 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpeas contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of a soil varies according to its origin and the kind of farming practiced. Even virgin soils are found that are deficient in phosphorus.

On all lands deficient in phosphorus (except on those susceptible to serious erosion by surface washing or gullying) that element should be applied in considerably larger amounts than are required to meet the actual needs of the crops desired to be produced. The abundant information thus far secured shows positively that fine-ground natural rock phosphate can be used successfully and very profitably, and clearly indicates that this material will be the most economical form of phosphorus to use in all ordinary systems of permanent, profitable soil improvement. The first application may well be one ton per acre, and subsequently about one-half ton per acre every four or five years should be applied, at least until the phosphorus content of the plowed soil reaches 2,000 pounds per acre, which may require a total application of from 3 to 5 or 6 tons per acre of raw phosphate containing 12½ percent of the element phosphorus.

Steamed bone meal and even acid phosphate may be used in emergencies, but it should always be kept in mind that a pound of phosphorus delivered in Illinois in the form of raw phosphate (direct from the mine in carload lots), is much cheaper than the same amount in steamed bone meal or in acid phosphate, both of which cost too much per ton to permit their common purchase by farmers in carload lots, which is not the case with raw phosphate. Landowners should bear in mind the fact that phosphorus additions to the soil in amounts above the immediate crop requirements represent a permanent investment, since this element is not readily lost in the drainage water as in the case of nitrogen. It is removed from the farm thru the sale of crops, milk, and animals.

Phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the fine-ground rock phosphate be intimately mixed with the organic material as it is plowed under.

The Potassium Problem

Normal soils, in which clay and silt form a considerable part of the constituency, are well stocked with potassium, altho it exists largely in insoluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be supplied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of normal soils are concerned, that the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have practically the same power as potassium to increase crop yield in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much

potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn. but the cheaper salt, kainit, was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part perhaps because the potassium removed in the crops is mostly returned in the manure if properly cared for, and perhaps in larger part because the decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no plant food of value.

In considering the conservation of potassium on the farm it should be remembered that in average live-stock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in live-stock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by the actual crop requirements for plant food, magnesium and calcium are more limited in some Illinois soils than potassium. But with these elements we must also consider the loss by leaching.

Doctor Edward Bartow and associates, of the Illinois State Water Survey, have shown that as an average of 90 analyses of Illinois well-waters drawn chiefly from glacial sands, gravels, or till, 3 million pounds of water (about the average annual drainage per acre for Illinois) contained 11 pounds of potassium, 130 of magnesium, and 330 of calcium. These figures are very significant, and it may be stated that if the plowed soil is well supplied with the carbonates of magnesium and calcium, then a very considerable proportion of these amounts will be leached from that stratum. Thus the loss of calcium from the plowed soil of an acre at Rothamsted, England, where the soil contains plenty of limestone, has averaged more than 300 pounds a year as determined by analyzing the soil in 1865 and again in 1905. And practically the same amount of calcium was found by analyzing the Rothamsted drainage waters.

Common limestone, which is calcium carbonate ($CaCO_3$), contains, when pure, 40 percent of calcium, so that 800 pounds of limestone is equivalent to 320 pounds of calcium. Where 10 tons per acre of ground limestone was applied at Edgewood, Illinois, the average annual loss during the next ten

years amounted to 790 pounds per acre. The definite data from careful investigations seems to be ample to justify the conclusion that where limestone is needed at least 2 tons per acre should be applied every four or five years.

It is of interest to note that thirty crops of clover of 4 tons each would require 3,510 pounds of calcium, while the most common prairie land of southern Illinois contains only 3,420 pounds of total calcium in the plowed soil of an acre. Thus limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of surfur, such as exists in our common types of soil, and an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply to conditions in Illinois.

Physical Improvement of Soils

In the management of most soil types, one very important thing, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is

organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is being destroyed during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, corn stalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and corn stalks should be turned under, and not burned. Probably no form of organic matter acts more beneficially in producing good tilth than corn stalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of corn stalks is one and one-half times that of a ton of manure, and a ton of dry corn stalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the corn stalks during the winter and often rather late in the spring after the frost is out of the ground. This tramping by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The bad effect will be greater if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including a liberal use of legumes, in order to increase the organic matter of the soil either by plowing under the legume crops and

other crop residues (straw and corn stalks), or by using for feed and bedding practically all the crops raised and returning the manure to the land with the least possible loss. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations, applicable to the corn belt, which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover) or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in live-stock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be seeded four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Wheat (with clover)
Second year —Corn
Third year —Oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Wheat or oats (with colver)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotation

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover especially as a green manure for building up depleted soils, as well as a pasture and hay crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields Representing the More Important Types of Soil Occurring in McHenry County)

In the earlier reports of this series it was the practice to incorporate in the body of the report the results of certain experiment fields, for the purpose of illustrating the possibilities of improving the soil of various types. The information carried by such data must, naturally, be considered more or less tentative. As the fields grow older new facts develop, which in some instances may call for the modification of former recommendations. It has therefore seemed desirable to separate this experiment field data from the more permanent information of the soil survey, and embody the same in the form of a supplement to the soil report proper, thus providing a convenient arrangement for possible future revisions as further data accumulate.

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the summarized results from certain of these fields which are representative of the types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

These fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots and each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, live-stock and grain farming. *In the live-stock system,* stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are supplied in the form of plant manures, including plant residues produced, such as stalks and straw, along with leguminous catch crops plowed under.

Rotations

Crops which are of interest in the respective localities are grown in definite rotations, and on most of the fields provision is made so that every crop in the rotation is represented every year. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. In the event of clover failure, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—All crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application are: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, the equivalent of 200 pounds of kainit. The initial application of limestone is usually 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

BROWN SILT LOAM

Several experiment fields have been conducted on brown silt loam soil at various locations in Illinois. Those located at the University have been in operation the longest and they serve well to illustrate the principles involved in the maintenance and improvement of this type of soil.

The Morrow Plots

It happens that the oldest soil experiment field in the United States is located on typical brown silt loam of the early Wisconsin glaciation, on the campus of the University of Illinois. This field was started in 1879 by George E. Morrow, who for many years was Professor of Agriculture, and these plots are known as the Morrow plots.

TABLE 1.—URBANA FIELD, MORROW PLOTS: BROWN SILT LOAM; PRAIRIE; EARLY WISCONSIN GLACIATION

Crop Yields in Soil Experiments—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
		Corn	Corn	Oats	Corn	Oats	Clover
1879–87	None.......	....	....	....	....	....	....
1888	None.......	54.3	49.5	....	....	48.6	....
1889	None.......	43.2	....	37.4	....	....	(4.04)
1890	None.......	48.7	54.3	....	....	....	(1.51)
1891	None.......	28.6	33.2	....	....	....	(1.46)
1892	None.......	33.1	....	37.2	70.2	....	....
1893	None.......	21.7	29.6	....	34.1	....	....
1894	None.......	34.8	....	57.2	....	65.1	....
1895	None.......	42.2	41.6	....	....	22.2	....
1896	None.......	62.3	....	34.5	....	....	....
1897	None.......	40.1	47.0	....	....	....	....
1898	None.......	18.1	....	....	....	....	....
1899	None.......	50.1	44.4	....	53.5	....	....
1900	None.......	48.0	....	41.5	....	....	....
1901	None.......	23.7	33.7	....	34.3	....	....
1902	None.......	60.2	....	56.3	....	54.6	....
1903	None.......	26.0	35.9	....	....	....	(1.11)
1904	None.......	21.5	....	17.5	55.3	....	....
1904	MLP.......	17.1	....	25.3	72.7	....	....
1905	None.......	24.8	50.0	....	....	42.3	....
1905	MLP.......	31.4	44.9	....	....	50.6	....
1906	None.......	27.1	....	34.7	....	....	(1.42)[1]
1906	MLP.......	35.8	....	52.4	....	....	(1.74)[1]
1907	None.......	29.0	47.8	....	80.5	....	....
1907	MLP.......	48.7	87.6	....	93.6	....	....
1908	None.......	13.4	....	32.9	....	40.0	....
1908	MLP.......	28.0	....	45.0	....	44.4	....
1909	None.......	26.6	33.0	....	....	....	(.65)[2]
1909	MLP.......	31.6	64.8	....	....	....	(1.73)[3]
1910	None.......	35.9	....	33.8	58.6	....	....
1910	MLP.......	54.6	....	59.4	83.3	....	....
1911	None.......	21.9	28.6	....	....	20.6	....
1911	MLP.......	31.5	46.3	....	....	38.0	....
1912	None.......	43.2	....	55.0	....	....	16.3[1]
1912	MLP.......	64.2	....	81.0	....	....	20.0[1]
1913	None.......	19.4	29.2	....	33.8	....	....
1913	MLP.......	32.0	25.0	....	47.8	....	....
1914	None.......	31.6	....	33.6	....	39.6	....
1914	MLP.......	39.4	....	58.2	....	60.4	....
1915	None.......	40.0	49.0	....	....	....	24.2[1]
1915	MLP.......	66.0	81.2	....	....	....	27.1[1]
1916	None.......	11.2	....	37.5	27.8	....	....
1916	MLP.......	10.8	....	64.7	40.6	....	....
1917	None.......	40.0	48.4	....	....	68.4	....
1917	MLP.......	78.0	81.4	....	....	86.9	....
1918	None.......	13.6	....	27.2	....	....	(2.58)
1918	MLP.......	32.6	....	59.3	....	....	(4.04)
1919	None.......	24.0	30.8	....	52.2	....	....
1919	MLP.......	43.4	66.2	....	70.8	....	....
1920	None.......	28.2	....	37.2	....	52.2	....
1920	MLP.......	54.4	....	51.6	....	69.7	....

[1]Soybeans.
[2]In addition to the hay, .64 bushel of seed was harvested.
[3]In addition to the hay, 1.17 bushels of seed were harvested.

TABLE 2.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY
Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover
1888 to 1903		*16 crops*	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
	None.......	39.7	41.0	44.0	48.0	47.6	(2.03)
1904 to 1920		*17 crops*	*8 crops*	*9 crops*	*6 crops*	*6 crops*	*3 crops*
	None.......	26.6	39.6	34.4	51.4	43.9	(1.55)[1]
	MLP.......	41.1	62.2	55.2	68.1	58.3	(2.50)[1]

[1]One crop of soybean hay.

The Morrow series now consists of three plots divided into halves and the halves are subdivided into quarters. On one plot corn is grown continuously; on the second corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904, receiving standard applications of farm manure with cover crops grown in the one-crop and two-crop systems. Phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. At the same time the rate of subsequent application of both forms of phosphorus was reduced to one-fourth the quantity, or to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per year. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre with the intention of standardizing the application to the rate of 1,000 pounds of limestone per acre per year.

FIG. 1.—CORN ON THE MORROW PLOTS IN 1910

Table 1 gives the yearly records of the crop yields, and Table 2 presents the same in summarized form.

Summarizing the data from these Morrow plots into two periods with the second period beginning in 1904 when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oats production, while the averages for the three-year system show an increase in corn yield and decreases in oats and clover. Unfortunately the numbers of crops included in these last averages are too small to warrant positive conclusions.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

The Davenport Plots

Another set of plots on the University campus at Urbana, forming a more extensive series than the Morrow plots, but of more recent origin, are the Davenport plots. Here each crop in the rotation is represented every year. These plots were laid out in 1895, but special soil treatment was not begun until 1901. They now comprize five series of ten plots each, and each series constitutes a "field" in a crop rotation system.

From 1901 to 1911 three of the series were in a three-year rotation system of corn, oats, and clover, while the remaining two series rotated in corn and oats. In 1911 these two systems were combined into a five-series field, with a crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field. The alfalfa occupies one series during a rotation of the other four crops, shifting to another series in the fifth year, thus completing the cycle of all series in twenty-five years.

The soil treatment applied to these plots has been as follows:

Legume cover crops were seeded in the corn at the last cultivation on Plots 2, 4, 6, and 8, from 1902 to 1907, but the growth was small and the effect, if any, was to decrease the returns from the regular crops. Crop residues (**R**) have been returned to these same plots since 1907. These consist of stalks and straw, and all legumes except alfalfa hay and the seed of clover and soybeans. Beginning in 1918 a modification of the practice was made in that one cutting of the red clover crop is harvested as hay. In conjunction with these residues a catch crop of sweet clover grown with the wheat is plowed under.

Manure (**M**) was applied preceding corn, at the rate of 2 tons per acre per year in 1905, 1906, and 1907; subsequently as many tons have been applied as there have been tons of air-dry produce harvested from the respective plots.

Lime (**L**) was applied on Plots 4 to 10 at the rate per acre of 250 pounds of air-slaked lime in 1902, and 600 pounds of limestone in 1903. No further application was made until 1911, when the system of cropping was changed. Since that time applications of limestone have been made at the rate of one-half ton per acre per year.

Phosphorus (**P**) was applied on Plots 6 to 9 at the rate of 25 pounds per acre per annum in 200 pounds of steamed bone meal; but beginning with 1908 rock phosphate at the rate of 600 pounds per acre per annum was substi-

TABLE 3.—URBANA FIELD, DAVENPORT PLOTS: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Ten-Year Average Annual Yields—Bushels or (tons) per acre
1911-1920

Serial plot No.	Soil treatment applied	Corn	Oats	Wheat	Clover 5 crops	Soybeans 5 crops	Alfalfa
1	0	55.6	50.5	26.0	(2.42)	(1.47)	(2.43)
2	R	57.1	52.3	28.7	1.47[1]	19.8	(2.46)
3	M	66.3	61.9	28.2	(2.56)	(1.62)	(2.52)
4	RL	64.8	55.6	31.4	1.61[1]	20.3	(2.72)
5	ML	69.6	64.1	32.8	(2.90)	(1.67)	(3.03)
6	RLP	71.5	69.8	43.0	2.29[1]	23.5	(3.69)
7	MLP	73.0	68.6	40.0	(3.52)	(1.97)	(3.76)
8	RLPK	70.9	72.5	40.7	1.79[1]	25.5	(3.77)
9	MLPK	70.2	72.0	39.2	(3.40)	(2.20)	(3.73)
10	Mx5LPx5	65.9	71.4	40.6	(3.31)	(2.22)	(3.77)

[1]In addition to the clover seed, a crop of hay was harvested one year on Plots 2, 4, 6, and 8, yielding 2.38, 2.20, 2.54, and 2.39 tons, respectively.

tuted for the bone meal on one-half of each of these plots. These applications continued until 1918 when adjustments were begun, first to make the rate of application of rock phosphate four times that of the bone meal, and finally to reduce the amounts of these materials to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per annum. The usual practice has been to apply and plow under at one time all phosphorus and potassium required for the rotation.

Potassium (**K** = kalium) has been applied on Plots 8 and 9 in connection with the bone meal and rock phosphate, at the yearly rate of 42 pounds per acre, and mainly as potassium sulfate.

On Plot 10 about five times as much manure and phosphorus are applied as on the other plots, but this "extra heavy" treatment was not begun until 1906, only the usual lime, phosphorus, and potassium having been applied in previous years. The purpose in making these heavy applications is to try to determine the climatic possibilities in crop yields by removing the limitations of inadequate fertility.

It will be observed that the applications described above provide for the two rather distinct systems of farming already described. *The grain system,* in which animal manure is not produced and where the organic matter is provided by the direct return to the soil of all crop residues, is exemplified in Plots 2, 4, 6, and 8; and the *live-stock system,* in which farm manure is utilized for soil enrichment, is represented in Plots 3, 5, 7, and 9.

Table 3 shows a summary of the results obtained on the Davenport plots beginning with the year 1911, when the present cropping system was introduced.

When used in conjunction with phosphorus the crop residues and the manure appear about equally effective; but where phosphorus is not applied, the manure has been decidedly more effective, under the conditions of the experiment. It should be observed, however, in this connection, that the plowing under of clover is a very essential feature of the residues system, and that, as a matter of fact, there were five clover failures, when soybeans were substituted, during the ten years. Perhaps with a more reliable biennial legume than red clover, the results would have been more favorable for this system.

Manure
Yield: 1.43 tons per acre

Manure, limestone, phosphorus
Yield: 2.90 tons per acre

FIG. 2.—CLOVER ON THE DAVENPORT PLOTS IN 1913

By comparing Plots 2 and 3 with Plots 4 and 5, it is found that limestone has had a beneficial effect on all crops. What the financial profit amounts to depends obviously upon the market value of the crops and the cost of the limestone.

Comparing Plots 4 and 5 with Plots 6 and 7, respectively, there is found in all cases an increase in crop yield as a result of adding phosphorus. The effect on wheat is especially pronounced. Where limestone and phosphorus are applied in addition to the crop residues, an increase of 17 bushels of wheat, over the yield of the untreated land, has been obtained as a ten-year average.

The effect of adding potassium to the treatment is of much interest. Plots 8 and 9 are the same as Plots 6 and 7, respectively, except that potassium has been applied to the former. On the whole, no significant benefit is shown from the addition of potassium.

No benefit appears as the result of the extra-heavy applications of manure and phosphorus on Plot 10. In fact the corn yields are noticeably less here than on the plots receiving the normal applications of these materials.

The University South Farm

On the University South Farm, at Urbana, several series of plots devoted primarily to variety testing and other crop-production experiments are so laid out as to show the effects of certain soil treatments that have been applied.

Several different systems of crop rotation are employed and the crops are so handled as to exemplify the two general systems of farming, grain and live-stock.

The summarized results presented in Table 4 represent three different systems of cropping. The first, designated as the Southwest rotation, is to be regarded as a good rotation for general practice, on this type of soil, under Illinois conditions. This is a four-field rotation of wheat, corn, oats, and clover. The second, or North-Central rotation, consisting of corn, corn, oats, and clover, represents a system very commonly practiced; and the third or South-Central rotation, consisting of corn, corn, corn, and soybeans, must be considered as a poor rotation from the standpoint of maintaining the productiveness of the land.

TABLE 4.—URBANA FIELD, SOUTH FARM: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Southwest Rotation: Series 100, 200, 400[1]: Wheat, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 9 crops	Oats[3] 9 crops	Wheat[3] 8 crops	Clover[4] 3 crops	Soybeans 7 crops
RP	62.3	51.9	41.0	1.05	17.3[5]
R	51.9	46.5	26.9	1.38	16.2[5]
M	59.7	50.2	29.1	(2.28)	(1.25)
MP	64.3	55.4	43.1	(2.86)	(1.51)
RLP	60.5	57.2	41.8	.64	16.4[5]
R	49.7	49.6	25.8	.83	14.7[5]
M	55.5	54.1	27.8	(1.71)	(1.28)
MLP	64.1	59.6	43.9	(1.77)	(1.58)

North-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Oats 9 crops	Clover 5 crops	Soybeans 4 crops
RP	56.7	51.1	56.1	.54	16.9
R	51.7	45.2	52.0	.50	16.0
M	54.9	46.7	52.1	(2.29)	(1.60)
MP	56.5	53.4	56.9	(2.73)	(1.74)

South-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Corn, Soybeans

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Corn 3d year 9 crops		Soybeans 9 crops
RP	51.9	44.0	41.3		20.0
R	45.5	39.9	35.2		19.2
M	50.1	42.1	33.5		(1.59)
MP	54.5	46.7	42.0		(1.66)

[1]Results from Series 300 and 800 are omitted on account of variation in soil type.
[2]Soybeans when clover fails.
[3]Only seven crops with limestone.
[4]Only one crop with limestone.
[5]Average of five crops.
[6]All phosphorus plots received ½ ton per acre of limestone in 1903.

TABLE 5.—COMPARING PRODUCTION OF CORN IN THREE DIFFERENT ROTATION SYSTEMS
ACRE YIELDS FROM PLOTS ON THE UNIVERSITY SOUTH FARM
Twelve-Year Average (1908-1919)—Bushels per acre

Rotation	Wheat-corn-oats-legume[1]	Corn-corn-oats-legume[2]		Corn-corn-corn-legume[3]		
Treatment	Corn	1st Corn	2d Corn	1st Corn	2d Corn	3d Corn
Organic manures	55.8	53.3	46.0	47.8	41.0	34.3
Organic manures, phosphorus	63.2	56.6	52.3	53.2	45.3	41.6

[1]Clover 3 crops, and soybeans 7 crops.
[2]Clover 5 crops, and soybeans 5 crops.
[3]Soybeans 9 crops.

On the whole, the "residues" have not returned yields quite so high as those produced by the manure treatment; but, as remarked above in the discussion of the Davenport plots, the residues system has probably been at a disadvantage thru frequent clover failures. On the North-Central rotation, where conditions seem to have been more favorable for clover, there is very little difference between the effect of manure and of residues.

Residues plowed under
Yield: 35.2 bushels per acre

Residues and rock phosphate
Yield: 50.1 bushels per acre

FIG. 3.—WHEAT ON THE UNIVERSITY SOUTH FARM IN 1911

In the rotation system in which limestone is being applied, no benefit of consequence to any of the crops except oats appears from the use of this material. The test, however, has hardly been of sufficient duration to warrant final conclusions; and furthermore, the comparison may be somewhat impaired by a possible residual effect of the small application of limestone made in 1903 to all the phosphorus plots.

The results obtained from the use of phosphorus are important because this element has been applied to these plots solely in the form of raw rock phosphate. The figures in almost every case show an increase in yield where the phosphorus has been applied, and in most cases this increase is very pronounced. The wheat is especially responsive to phosphorus.

The records furnish some interesting comparisons of corn yields produced under different systems of cropping. Table 5 gives a general summary of the corn yields only, in which the results from the residues and manure treatments are averaged together as "organic manures." The highest annual acre-yields are found where corn occurs but once in a rotation. Where corn is grown twice in succession, the annual acre-yields are less; and where corn occurs three times, there is a further reduction. Also, the first crop of corn within a rotation produces more than the second, and the second crop yields more than the third. These are useful facts for consideration in connection with problems of general farm management.

YELLOW-GRAY SILT LOAM

Yellow-gray silt loam exhibits an important variation with respect to limestone content. In some areas, altho limestone may be altogether absent in the surface stratum it is found in abundance at a short distance beneath the surface. Accordingly, variations in response to soil treatment are exhibited by different experiment fields located on this type. In view of this discrepancy it is thought well to introduce here the records of two fields, that are representative of the type but which show a marked diversity in results, one in northern Illinois and one in the southern part of the state.

The Antioch field is located on the late Wisconsin glaciation, in Lake county, close to the Wisconsin border. The field was started in 1902, with but a single series of ten plots, under a rotation of corn, corn, oats, and wheat; but beginning with 1911 the rotation has been wheat, corn, oats, and clover. It was started in order to learn as quickly as possible what effect would be produced by the addition to this type of soil of nitrogen, phosphorus, and potassium, used singly and in combination. These elements were all applied in commercial form until 1911, after which the use of commercial nitrogen was discontinued and crop residues were substituted in its place. Nitrogen was supplied in the earlier years in 800 pounds per acre of dried blood. Phosphorus is applied in 200 pounds of steamed bone meal, and potassium in 100 pounds of potassium sulfate. At the beginning, 470 pounds of slaked lime was applied; but since 1912 limestone has been applied at the rate of 1,000 pounds per acre per year.

Table 6 presents, in summarized form, the results from the Antioch field. Because of an abnormality in Plot 1, the results from this plot are not considered. The data show that phosphorus is the one element standing out prominently as producing consistently beneficial results. Potassium applied in addition to phosphorus has, on the whole, not produced profitable results. Also, the

TABLE 6.—ANTIOCH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LATE WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 8 crops	Oats 5 crops	Wheat 4 crops	Clover seed 2 crops
1	0	23.9	32.3	15.8	.50
2	L	21.3	26.8	13.2	.30
3	LR	21.3	29.9	20.6	.33
4	LP	30.7	43.6	36.7	1.08
5	LK	23.7	27.8	19.2	.57
6	LRP	33.8	43.3	33.3	.57
7	LRK	24.3	26.9	20.8	.59
8	LPK	25.1	38.2	30.9	1.26
9	LRPK	38.3	42.6	28.0	.33
10	RPK	38.4	44.7	30.2	.67

Lime applied and residues plowed under

Lime and phosphorus applied

FIG. 4.—CLOVER IN 1913 ON ANTIOCH FIELD

results are unfavorable for the application of limestone. Limestone, however, is abundant in the subsoil of this type in the region of this field.

The Raleigh experiment field is located on the lower Illinoisan glaciation, in southern Illinois, in Saline county. This field is laid out into four series of ten plots each, under a rotation of wheat, corn, oats, and clover. The treatments, along with the summarized results, are given in Table 7.

Manure, limestone, phosphorus
Yield: 61 bushels per acre

Nothing applied
Yield: 15 bushels per acre

FIG. 5.—CORN ON RALEIGH FIELD IN 1920

TABLE 7.—RALEIGH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LOWER ILLINOISAN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 10 crops	Oats 10 crops	Wheat 6 crops	Clover 4 crops		Soybeans 4 crops
1	0	17.3	10.4	5.8	(.26)		(.65)
2	M	29.7	13.0	7.7	(.31)		(.81)
3	ML	40.9	20.0	21.0	(1.08)		(1.08)
4	MLP	41.2	20.3	21.5	(1.32)		(1.24)
5	0	17.3	10.3	7.0	(.00)	.01[2]	2.3
6	R	20.1	12.8	8.4	(.00)	.01[2]	3.0
7	RL	34.9	21.5	18.8	(1.60)[1]	.10[2]	5.8
8	RLP	36.5	22.7	21.2	(1.61)[1]	.09[2]	6.8
9	RLPK	41.9	23.6	22.4	(1.79)[1]	.12[2]	6.0
10	0	19.6	11.6	6.5	(1.06)		(.57)

[1]One crop only (1920).
[2]Average of two crops.

The outstanding feature of these results is the effect of limestone. Altho manure alone produces a substantial increase, especially in the corn crop, when limestone is added a remarkable increase is found in all crops. A most important fact is that the organic matter can be effectively built up thru the use

of crop residues, with the application of limestone, so that the crop yields are practically as high under this "grain system" of farming as where manure is used.

Phosphorus thus far has given only moderate returns in increased crop yields, but with an increasing quantity of organic matter and nitrogen it is probable that the phosphorus applications will show up more favorably on subsequent crops. As to the use of potassium, it is to be noted that aside from an increase of 5.4 bushels of corn in the residues system, the beneficial effect has not been sufficient to justify the use of this material.

In accounting for the discrepancy in the response to limestone on these two fields, the fact is to be considered that the Antioch field is located on the late Wisconsin glaciation, where the subsoil contains large quantities of limestone; while the Raleigh field represents the lower Illinoisan glaciation, the soil of which is very acid to a great depth.

In view of these variations, a general recommendation for a complete treatment for soil of this type, that will apply to all localities, cannot be given out until more information is acquired.

Fortunately, however, each farmer can determine for himself the need of limestone for his land by applying the simple tests for the presence of carbonates and soil acidity, as explained under the discussion of limestone on page 29 of the Appendix.

Phosphorus, which has paid well on the Antioch field, and has given doubtful returns thus far at Raleigh, has varied considerably in its effect when used on other fields located on this same type of soil. In this situation, therefore, the present suggestion would be that each farmer might well try out phosphorus on his own land, on a limited scale, and be guided by the outcome of his experience. The low phosphorus content of the surface stratum of this soil is an indication that in a system of permanent agriculture the time is not far off when phosphorus will become a limiting element to crop production, and the wise farmer will watch carefully the indications and be ready to make timely provision for this need.

Deep Peat

As representing the deep peat type of soil, the results are introduced from an experiment field conducted at Manito in Mason county during the years 1902 to 1905 inclusive.

There were ten plots receiving the treatments indicated in Table 8.

The results of the four years' tests, as given in Table 8, are in complete harmony with the information furnished by the chemical composition of peat soil. Where potassium was applied, the yield was from three to four times as large as where nothing was applied. Where approximately equal money values of kainit and potassium chlorid were applied, slightly greater yields were obtained with the potassium chlorid, which, however, supplied about one-third more potassium than the kainit. On the other hand, either material furnished more potassium than was required by the crops produced.

The use of 700 pounds of sodium chlorid (common salt) produced no appreciable increase over the best untreated plots, indicating that where potassium is itself actually deficient, salts of other elements cannot take its place.

TABLE 8.—MANITO FIELD: DEEP PEAT
Corn Yields—Bushels

Plot No.	Soil treatment for 1902	Corn 1902	Corn 1903	Soil treatment for 1904	Corn 1904	Corn 1905	Four crops
1	None	10.9	8.1	None	17.0	12.0	48.0
2	None	10.4	10.4	Limestone, 4000 lbs.	12.0	10.1	42.9
3	Kainit, 600 lbs	30.4	32.4	Limestone, 4000 lbs.; Kainit, 1200 lbs.	49.6	47.3	159.7
4	Kainit, 600 lbs.; Acidulat'd bone, 350 lb.	30.3	33.3	Kainit, 1200 lbs.; Steamed bone, 395 lbs.	53.5	47.6	164.7
5	Potassium chlorid, 200 lbs.	31.2	33.9	Potassium chlorid, 400 lbs.	48.5	52.7	166.3
6	Sodium chlorid, 700 lbs.	11.1	13.1	None	24.0	22.1	70.3
7	Sodium chlorid, 700 lbs.	13.3	14.5	Kainit, 1200 lbs.	44.5	47.3	......
8	Kainit, 600 lbs.	36.8	37.7	Kainit, 600 lbs.	44.0	46.0	164.5
9	Kainit, 300 lbs.	26.4	25.1	Kainit, 300 lbs.	41.5	32.9	125.9
10	None	14.9[1]	14.9	None	26.0	13.6	69.4

[1]Estimated from 1903; no yield was taken in 1902 because of a misunderstanding.

Applications of 2 tons per acre of ground limestone produced no increase in the corn crops, either when applied alone or in combination with kainit, either the first year or the second.

Reducing the application of kainit from 600 to 300 pounds for each two-year period reduced the yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainit (Plot 9) furnished 60 pounds of potassium for the four years, an amount sufficient for 84 bushels of corn (grain and stalks). Attention is called to the fact that this is practically the difference between the yield of Plot 9 (125.9 bushels) and the yield obtained from Plot 2 (42.9 bushels), the poorest untreated plot.

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 22

IROQUOIS COUNTY SOILS

By J. G. MOSIER, S. V. HOLT, E. VAN ALSTINE
and H. J. SNIDER
Prepared for publication by L. H. SMITH

URBANA, ILLINOIS, JANUARY, 1922

IN RECOGNITION

The Soil Survey of Illinois was organized under the supervision of the late Dr. Cyril G. Hopkins. The work progressed for eighteen years under his guidance and the first eighteen soil reports bear his name as senior author. On October 6, 1919, Dr. Hopkins died in a foreign land in the service of the American Red Cross. It is the purpose to carry on to completion this great work of the Illinois Soil Survey in the spirit, and along the same general plan and lines of procedure, in which it was begun.

INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or land owner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and land owner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

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IROQUOIS COUNTY SOILS

APPENDIX

SUPPLEMENT

IROQUOIS COUNTY SOILS

By J. G. MOSIER, S. V. HOLT, E. VAN ALSTINE, and H. J. SNIDER

Prepared for Publication by L. H. SMITH[1]

FORMATION

Iroquois county is situated on the eastern border of Illinois about one hundred miles south of the north line. The county measures approximately thirty-three by thirty-four miles, and comprizes an area of 1,123.62 square miles.

The most important period in the geological history of the county from the standpoint of soil formation was that during which the material that later formed the soils was being deposited. This was the Glacial period. At that time snow and ice accumulated in the region of Labrador, west of Hudson Bay, and in the Rocky Mountains to such an amount that the mass pushed outward from these centers, especially southward, until a point was reached where the ice melted as rapidly as it advanced. As the ice advanced in these movements it buried everything, even the highest mountains, in its path. It would then recede slowly, and apparently normal conditions would be restored for a long period, after which another advance would occur. At least six of these great ice movements took place, each of which covered some part of northern United States, altho the same parts were not covered every time.

In advancing from these distant northern centers of accumulation, the ice gathered up all sorts and sizes of material, including clay, silt, sand, gravel, boulders, and even large masses of rock. Some of these materials were carried several hundred miles, and the coarser masses rubbed against the surface rocks or against each other until largely ground into rock powder, which now constitutes much of the soil. As the ice melted upon reaching the limit of advance, the material was dropped. If the glacier remained in the same position for some time, this material accumulated in a broad undulating ridge called a lateral moraine if formed at the side of the glacier, or a terminal moraine if formed at the end. When the ice melted more rapidly than the glacier advanced, the terminus of the glacier receded and the material was deposited somewhat irregularly over the land, back of the moraines. This formation is known as a ground moraine. A glacier would often advance again, but not so far as before; or it would remain stationary, and another moraine would be built up. These moraines, or ridges, have a steep outward slope and a very gradual inward slope.

A pressure of forty pounds per square inch is exerted by a mass of ice one hundred feet thick, and these ice sheets may have been hundreds or even thousands of feet in thickness. The materials carried along in the ice, especially the boulders and pebbles, became powerful agents for grinding and wearing away the surface over which the ice passed. Preglacial ridges and hills were rubbed

[1] J. G. Mosier, in charge of soil survey mapping; S. V. Holt, in charge of field party; E. Van Alstine, in charge of soil analysis; H. J. Snider, in charge of experiment fields; L. H. Smith, in charge of publications.

down, valleys were filled with the debris, and the surface features were changed entirely. The mixture of materials deposited by the glacier is known as boulder clay, till, glacial drift, or simply drift.

THE GLACIATIONS OF IROQUOIS COUNTY

There were at least four ice advances that reached Iroquois county and covered it wholly or in part. The first advance that reached this county was probably the Illinoisan glacier, which covered all of Illinois except the northwest corner (practically all of Jo Daviess county), the southern part of Calhoun county, and the seven southernmost counties. (See state map in Bulletin 123 or 193). This glacier melted and somewhat normal conditions were restored, as is indicated by the thick soil formed from the material deposited by the glacier.

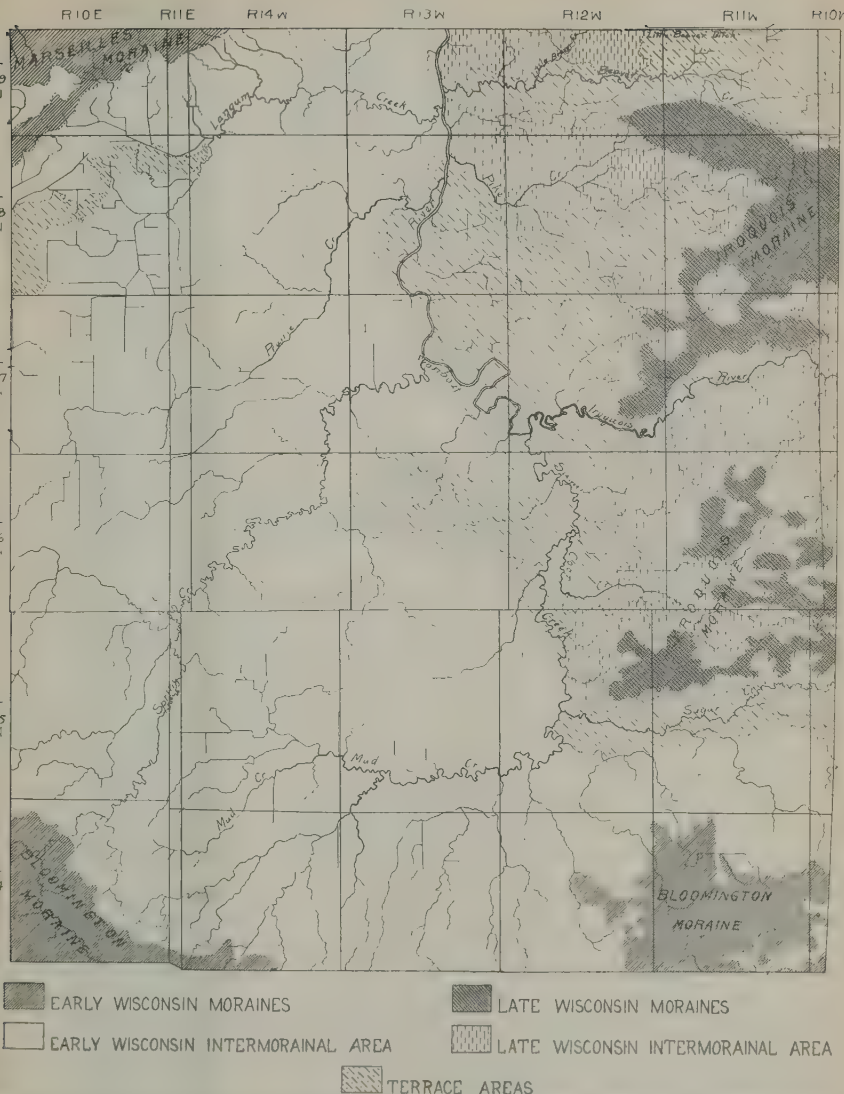
The drift left by this ice sheet was buried by another glacier, probably the Iowan; and this was followed by a third, known as the early Wisconsin. The material deposited by the early Wisconsin glacier forms most of the surface material west of the Iroquois river and south of Sugar creek. The moraine appearing in the southeastern and southwestern parts of Iroquois and bending down into the northern part of Vermilion county is known as the Bloomington moraine. Another moraine was built up by the early Wisconsin glacier along the northern boundary of Kankakee county and west of the Iroquois river. This is known as the Marseilles moraine.

The late Wisconsin glacier covered most of the county east of the Iroquois river and north of Sugar creek. A more or less distinct moraine found here is called the Iroquois moraine. This moraine is quite characteristically developed near Beaverville in the northeastern part of the county.

PHYSIOGRAPHY AND DRAINAGE

The county varies in topography from flat to slightly rolling. Even along the streams hills do not exist to any extent. The principal variations are due to the irregular deposition of glacial material, the depth of which varies from a few feet to more than three hundred feet, and averages probably about one hundred and fifty feet. The moraines take the form of irregular billowy ridges, and they vary in width from a mile or two, to six or eight miles. A broad flat valley, comprizing a large part of the intermorainal area, lies between the three moraines. This valley was formerly very poorly drained. It contained extensive swamps and many ponds, which usually became dry during the summer. The marginal ridges, with the underlying sands and gravels of this valley or basin, have brought about conditions that give rise to artesian wells. Water is obtained at depths varying from 30 to 160 feet.

With the exception of a few small areas in the northwest part, the entire county is drained by the Iroquois river and its tributaries, the principal of which are the Langum, Prairie, and Spring creeks from the west, with Sugar, Pike, and Beaver from the east. These streams, together with the dredge ditches which have been made, now provide a very good system of drainage. Erosion topography is limited to the immediate vicinity of the streams. In some places the subsoil becomes too heavy and tight for good drainage.



MAP SHOWING THE DRAINAGE BASINS OF IROQUOIS COUNTY WITH MORAINAL, INTERMORAINAL, AND TERRACE AREAS

The altitudes of several places in Iroquois county are as follows: Ashkum, 670 feet above sea level; Buckley, 702; Chebanse, 674; Cissna Park, 684; Cissna Junction, 690; Claytonville, 665; Clifton, 672; Crescent City, 637; Danforth, 658; Donovan, 670; Del Ray, 669; Fountain Creek, 677; Gilman, 654; Goodwine, 660; Hickman, 677; Iroquois, 673; Loda, 780; LaHogue, 664; Martinton, 627; Milford, 666; Onarga, 676; Papineau, 630; Pittwood, 643; Sheldon, 688; Stockland, 695; Thawville, 696; Watseka, 634; Woodland, 640; Wellington, 698.

During the Glacial period, the drainage of the Great Lakes to the north and east was blocked by the ice, and the water necessarily found an outlet to the south thru the Illinois and Wabash rivers. The former drained Lake Michigan and Lake Huron in part, while the latter drained Lake Erie. At that time the basins of the Iroquois and Kankakee were temporary broad lakes. That of the Iroquois extended from Onarga to the Marseilles moraine and westward across Ford county into Livingston county, and it probably overflowed into the Vermilion river and thence to the Illinois river. These lakes were shallow and did not exist for any great length of time. They were succeeded by swamps that have been only recently drained.

SOIL MATERIAL AND SOIL TYPES

The glaciers that covered Iroquois county left a deposit called till, glacial drift, or boulder clay (a mixture of boulders, gravel, sand, silt, and clay), having an average thickness of about 150 feet. This deposit, however, does not form the soil material except in small areas. The rock flour produced by the grinding action of the glaciers was reworked by the wind and deposited over practically all of the county to a depth of 12 to 40 inches. This loessial, or wind-blown material now covering the level and less rolling areas, has been transformed into soil by weathering and by the accumulation of organic matter. There is little doubt but that this wind-blown material was at one time fairly uniformly deposited over the exposed surface, but it has subsequently been removed in places by erosion, so that the boulder clay is exposed on some of the more rolling areas. The deposit is thicker on the early Wisconsin glaciation than on the late Wisconsin, because of a deeper original deposit (3 to 6 feet) and because there has not been so much erosion on this less rolling area.

During the melting of the glacier the streams draining this area were frequently flooded and carried large amounts of rather coarse material, such as gravel and sand. This was deposited in the valleys, partly filling them. Later the streams cut down thru the fill, leaving gravel terraces. This gravel was later covered with the fine material that now constitutes the soil. These terraces occur principally along Sugar creek, and in broad irregular expansions along the Iroquois river and to the northeast part of the county along Beaver creek. Part of this area, constituting the expansion south of Martinton, was produced by the breaking of the water over the moraine south and east of Hooper. Much sand was deposited by this overflow and this area south of Martinton contains many sand dunes.

The soils of Iroquois county are divided into the following groups:

(a) Upland Prairie Soils, including the upland soils that have not been covered with forests and on which the luxuriant growth of prairie grasses has produced relatively large amounts of organic matter.

(b) Upland Timber Soils, including nearly all the upland areas that are now, or were formerly, covered with forests.

(c) Terrace Soils, including bench lands, or second bottom lands, formed by deposits from overloaded streams, or by broad sheets of water arising from the melting of the glaciers.

(d) *Swamp and Bottom-Land Soils,* including the overflow lands or flood plains along streams, the swamps, and the poorly drained lowlands.

Table 1 gives a list of the types of soil found in Iroquois county, the area of each type in square miles and in acres, and its percentage of the total area. For example, it may be noted that the brown silt loam of the prairie occupies sixty percent of the area of the county. The accompanying map shows the location and boundary of each type of soil, even down to areas of a few acres.

For explanations concerning the classification of soils and the interpretation of the map and tables, the reader is referred to the first part of the Appendix to this report.

TABLE 1.—SOIL TYPES OF IROQUOIS COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (900, 1000, 1100, 1200)			
-26	Brown silt loam	681.81	436,358	60.68
-20	Black clay loam	80.46	51,494	7.16
-60	Brown sandy loam	106.37	68,077	9.45
-81	Dune sand	4.65	2,976	.41
-28	Brown-gray silt loam on tight clay	1.33	851	.12
-28.1	Brown silt loam on tight clay	7.36	4,710	.66
		881.98	564,466	78.48
	(b) Upland Timber Soils (900, 1000, 1100, 1200)			
-34	Yellow-gray silt loam	16.74	10,714	1.49
-64	Yellow-gray sandy loam	4.48	2,867	.40
-35	Yellow silt loam	1.58	1,011	.14
-38	Yellow-gray silt loam on tight clay	1.60	1,024	.14
		24.40	15,616	2.17
	(c) Terrace Soils (1500)			
-60	Brown sandy loam	108.30	69,312	9.64
-26	Brown silt loam	2.66	1,702	.24
-27	Brown silt loam over gravel	13.20	8,448	1.18
-64	Yellow-gray sandy loam	9.14	5,850	.81
-81	Dune sand	18.50	11,840	1.65
-34	Yellow-gray silt loam	.46	294	.04
-36	Yellow-gray silt loam over gravel	6.37	4,077	.57
-66	Brown sandy loam over gravel	4.98	3,187	.44
-67	Yellow-gray sandy loam over gravel	3.30	2,112	.29
-26.4	Brown silt loam on gravel	.33	211	.03
-20	Black clay loam	.25	160	.02
		167.49	107,193	14.91
	(d) Swamp and Bottom-Land Soils (1400)			
-26	Deep brown silt loam	29.06	18,599	2.59
-54	Mixed loam	3.88	2,483	.35
-61	Black sandy loam	12.61	8,071	1.12
-10.2	Peaty loam on sand	.45	288	.04
-01	Deep peat	1.78	1,139	.16
-02	Medium peat on clay	.73	467	.07
-13	Clayey muck	.25	160	.02
		48.76	31,207	4.35
	Water	.99	634	.09
	Total	1,123.62	719,116	100.00

INVOICE OF PLANT FOOD IN IROQUOIS COUNTY SOILS

SOIL ANALYSIS

The composition reported in the accompanying tables is, for the more extensive types, the average of several analyses. These analyses, like most things in nature, show more or less variation, but for general purposes they may be considered sufficient to characterize the soil type.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed, but it should be understood that the rate of liberation, as explained in the Appendix (page 35), is governed by many factors.

THE SURFACE SOIL

In Table 2 are reported the amount of organic carbon (the best measure of the organic matter), and the total quantities of nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium contained in 2 million pounds of the surface soil (the plowed soil of an acre about 6⅔ inches deep) of each type in Iroquois county.

Because of the fact that soils often vary so extremely within the type with respect to the presence of limestone and acidity, no attempt is made to include in the tabulated results figures purporting to represent the average amounts of these substances present in the respective types. Such averages cannot give the farmer the specific information he needs regarding the lime requirements of a given field. Fortunately, however, very simple tests which can be made at home will furnish this important information, and these tests are described on page 37 of the Appendix.

The variation among the different types of soil with respect to the content of important plant-food elements is very marked. For example, the deep peat contains, in the plowed soil of an acre, more than thirty times as much nitrogen as does the dune sand. Comparing the deep peat with the most common type in the county, we find about five times as much nitrogen in it as in the brown silt loam, while on the other hand the brown silt loam contains more than eight times as much potassium as is found in the deep peat. The supply of phosphorus in the surface soil varies from 660 pounds per acre in the dune sand to 1,450 pounds in the deep brown silt loam. A sulfur content of 190 pounds per acre is found in the dune sand, while in the deep peat there are 4,310 pounds of this element. The magnesium varies in the different types from 2,900 to 18,280 pounds, and the calcium content ranges from 5,700 to 24,840 pounds per acre.

It is important to note that some of the plant-food elements are present in very limited quantities as compared with crop requirements. Some simple computations are of interest in this connection. Assume, for example, that a four-field crop rotation of wheat, corn, oats, and clover yields 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. It will be found that the most prevalent upland soil of Iroquois county, the brown silt loam, contains only enough total nitrogen in the plowed soil for the production of such yields to supply about ten rotations.

TABLE 2.—PLANT FOOD IN THE SOILS OF IROQUOIS COUNTY, ILLINOIS: SURFACE SOIL
Average pounds per acre in 2 million pounds of surface soil (about 0–6⅔ inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (900, 1000, 1100, 1200)							
-26, 1526	Brown silt loam	65 020	5 300	1 060	920	39 700	10 590	10 670
-20	Black clay loam	65 260	6 160	1 310	1 030	42 260	16 600	19 450
-60	Brown sandy loam	57 880	4 700	1 270	990	23 900	6 390	24 840
-81, 1581	Dune sand	13 710	900	660	190	26 570	3 120	7 360
1128	Brown-gray silt loam on tight clay	44 180	3 840	1 060	760	32 320	7 060	8 260
1128.1	Brown silt loam on tight clay	46 860	4 240	860	460	39 900	9 620	10 020
	(b) Upland Timber Soils (900, 1000, 1100, 1200)							
-34	Yellow-gray silt loam	24 460	1 970	880	270	39 740	5 280	6 850
-64	Yellow-gray sandy loam	25 560	2 040	700	300	30 000	3 480	7 180
-35	Yellow silt loam	28 370	2 680	810	350	59 600	16 170	6 460
-38	Yellow-gray silt loam on tight clay	33 600	3 200	970	530	33 680	6 390	6 490
	(c) Terrace Soils (1500)							
-60	Brown sandy loam	55 770	4 880	1 170	990	23 610	5 020	16 970
-26, 926, 1026, 1126, 1226	Brown silt loam	65 020	5 300	1 060	920	39 700	10 590	10 670
-27	Brown silt loam over gravel	51 280	4 600	1 240	700	30 400	5 580	6 240
-64	Yellow-gray sandy loam	21 660	1 820	740	200	27 680	3 480	6 220
-81, 981, 1081, 1181, 1281	Dune sand	13 710	900	660	190	26 570	3 120	7 360
-34	Yellow-gray silt loam	34 620	3 040	1 040	400	46 420	9 580	8 560
-36	Yellow-gray silt loam over gravel	28 180	2 310	1 060	290	39 140	5 640	6 330
-66	Brown sandy loam over gravel	34 250	2 920	1 000	650	29 160	4 970	7 450
-67	Yellow-gray sandy loam over gravel	21 040	1 420	760	360	27 860	3 240	5 700
-26.4	Brown silt loam on gravel	35 720	2 880	1 080	380	28 240	5 280	6 000
-20	Black clay loam	57 980	5 220	1 380	760	34 760	14 440	17 320
	(d) Swamp and Bottom-Land Soils (1400)							
-26	Deep brown silt loam	70 060	5 860	1 450	1 320	46 770	18 280	22 280
-54	Mixed loam	77 040	6 700	1 280	1 800	28 620	6 800	9 060
-61	Black sandy loam	65 290	5 730	1 230	1 000	30 210	7 990	19 960
-10.2	Peaty loam on sand[1]	172 320	13 350	870	2 430	17 450	5 250	19 170
-01	Deep peat[2]	345 060	27 910	1 160	4 310	4 590	3 010	23 410
-02	Medium peat on clay[2]	211 120	16 040	730	2 990	8 600	2 900	18 660
-13	Clayey muck[1]	151 950	13 070	1 440	3 170	32 840	11 390	17 810

Limestone and Soil Acidity.—In connection with these tabulated data it should be explained that the figures on limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm, and even from field to field. Therefore no attempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, page 37.

[1]Amounts reported are for 1½ million pounds of peaty loam and clayey muck.
[2]Amounts reported are for 1 million pounds of deep peat and medium peat.

Table 3.—Plant Food in the Soils of Iroquois County, Illinois: Subsurface Soil
Average pounds per acre in 4 million pounds of subsurface soil (about 6⅔-20 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (900, 1000, 1100, 1200)							
26} 1526}	Brown silt loam	60 530	5 280	1 430	1 080	84 710	28 420	18 920
-20	Black clay loam	60 110	5 720	2 020	1 140	87 590	38 080	38 940
-60	Brown sandy loam	45 700	4 160	1 700	1 020	51 340	14 120	42 960
-81} 1581}	Dune sand	14 860	960	1 100	320	52 480	6 000	13 420
1128	Brown-gray silt loam on tight clay	49 240	4 280	1 440	760	76 280	19 520	13 520
1128.1	Brown silt loam on tight clay	47 200	4 640	1 200	480	84 200	25 080	15 080
	(b) Upland Timber Soils (900, 1000, 1100, 1200)							
-34	Yellow-gray silt loam	16 800	1 680	1 480	360	72 780	16 380	11 840
-64	Yellow-gray sandy loam	16 520	1 320	1 360	280	59 920	8 000	15 800
-35	Yellow silt loam	24 440	3 380	1 760	580	139 300	70 560	65 140
-38	Yellow-gray silt loam on tight clay	27 580	3 140	1 300	500	77 880	23 980	10 520
	(c) Terrace Soils (1500)							
-60	Brown sandy loam	41 940	3 710	1 550	850	51 250	11 050	25 270
-26} 926} 1026} 1126} 1226}	Brown silt loam	60 530	5 280	1 430	1 080	84 710	28 420	18 920
-27	Brown silt loam over gravel	49 120	4 720	1 760	720	64 280	13 720	10 080
-64	Yellow-gray sandy loam	11 360	1 200	1 200	280	58 000	9 640	11 080
-81} 981} 1081} 1181} 1281}	Dune sand	14 860	960	1 100	320	52 480	6 000	13 420
-34	Yellow-gray silt loam	32 440	3 320	1 600	520	99 680	31 960	11 400
-36	Yellow-gray silt loam over gravel	18 980	2 180	1 620	240	84 660	18 740	10 520
-66	Brown sandy loam over gravel	36 680	3 400	1 490	730	60 280	11 590	13 210
-67	Yellow-gray sandy loam over gravel	13 240	1 040	1 360	600	62 800	9 080	10 160
-26.4	Brown silt loam on gravel	38 160	3 400	1 600	480	59 680	11 640	9 840
-20	Black clay loam	51 720	4 800	2 080	720	68 880	28 920	36 160
	(d) Swamp and Bottom-Land Soils (1400)							
-26	Deep brown silt loam	118 740	10 320	2 680	2 080	91 660	32 900	35 380
-54	Mixed loam	33 280	3 080	1 040	600	62 280	11 680	13 960
-61	Black sandy loam	45 020	4 220	1 080	1 120	64 940	17 040	27 780
-10.2	Peaty loam on sand[1]	149 670	9 450	1 230	2 460	41 640	12 000	36 120
-01	Deep peat[2]	354 540	30 940	1 360	6 180	17 640	8 260	32 740
-02	Medium peat on clay[2]	114 180	8 820	820	2 120	23 360	4 600	18 360
-13	Clayey muck[1]	329 310	27 270	2 100	7 590	51 540	24 180	44 100

Limestone and Soil Acidity.—In connection with these tabulated data it should be explained that the figures on limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm, and even from field to field. Therefore no attempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, page 37.

[1]Amounts reported are for 3 million pounds of peaty loam and clayey muck.
[2]Amounts reported are for 2 million pounds of deep peat and medium peat.

TABLE 4.—PLANT FOOD IN THE SOILS OF IROQUOIS COUNTY, ILLINOIS: SUBSOIL
Average pounds per acre in 6 million pounds of subsoil (about 20-40 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (900, 1000, 1100, 1200)							
-26 1526	Brown silt loam............	29 150	3 300	2 020	1 180	147 660	86 810	107 680
-20	Black clay loam............	26 590	3 600	2 780	3 180	129 590	83 100	167 860
-60	Brown sandy loam.........	24 690	3 360	1 860	840	87 420	23 970	42 150
-81 1581	Dune sand.................	13 290	1 020	1 620	360	80 220	9 690	20 730
1128	Brown-gray silt loam on tight clay................	30 720	3 540	1 620	1 020	140 160	49 680	24 540
1128.1	Brown silt loam on tight clay	26 880	4 020	2 340	660	148 980	77 520	115 740
	(b) Upland Timber Soils (900, 1000, 1100, 1200)							
-34	Yellow-gray silt loam.......	12 360	1 800	2 070	300	116 970	35 610	20 670
-64	Yellow-gray sandy loam.....	11 760	1 020	1 800	300	85 260	14 400	21 300
-35	Yellow silt loam............	24 900	3 600	2 370	840	183 990	127 680	203 880
-38	Yellow-gray silt loam on tight clay................	21 750	3 690	2 100	930	142 230	61 500	22 800
	(c) Terrace Soils (1500)							
-60	Brown sandy loam.........	17 800	2 070	1 800	650	83 230	24 400	42 760
-26 926 1026 1126 1226	Brown silt loam............	29 150	3 300	2 020	1 180	147 660	86 810	107 680
-27	Brown silt loam over gravel..	23 400	2 760	2 280	1 020	93 900	28 080	20 400
-64	Yellow-gray sandy loam.....	15 720	2 220	1 800	240	114 720	31 200	18 360
-81 981 1081 1181 1281	Dune sand.................	13 290	1 020	1 620	360	80 220	9 690	20 730
-34	Yellow-gray silt loam.......	21 960	3 000	2 280	720	139 980	42 300	20 460
-36	Yellow-gray silt loam over gravel..................	15 060	2 250	1 890	240	119 970	32 310	20 160
-66	Brown sandy loam over gravel	22 920	2 580	1 840	580	99 760	24 560	24 200
-67	Yellow-gray sandy loam over gravel..................	13 320	1 920	2 220	240	105 300	22 860	15 840
-26.4	Brown silt loam on gravel...	19 620	2 160	1 980	180	90 420	19 980	13 380
-20	Black clay loam............	23 880	2 640	2 100	600	98 040	91 320	249 600
	(d) Swamp and Bottom-Land Soils (1400)							
-26	Deep brown silt loam.......	83 490	7 590	2 880	1 590	236 680	43 410	39 240
-54	Mixed loam................	22 980	2 220	960	420	102 420	22 320	17 880
-61	Black sandy loam..........	16 710	2 250	1 950	960	100 920	32 580	41 670
-10.2	Peaty loam on sand.........	19 740	1 140	1 560	1 560	68 820	34 320	271 560
-01	Deep peat[1]................	298 020	23 100	1 500	31 140	38 970	25 650	75 330
-02	Medium peat on clay.......	92 160	6 300	1 800	4 860	78 840	27 960	74 940
-13	Clayey muck...............	355 860	23 760	2 340	9 600	116 700	62 640	79 020

Limestone and Soil Acidity.—In connection with these tabulated data it should be explained that the figures on limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm, and even from field to field. Therefore no attempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, page 37.

[1]Amounts reported are for 3 million pounds of deep peat.

With respect to phosphorus, the condition differs only in degree, this soil containing no more of that essential element than would be required for about thirteen crop rotations yielding at the rates suggested above. On the other hand the amount of potassium in the surface layer of this common soil type is sufficient for more than 31 centuries if only the grain is sold, or for more than 600 years if the total crops should be removed from the land and nothing returned.

These general statements relating to the total quantities of these plant-food materials in the plowed soil of the most prevalent type in the county certainly emphasize the fact that the supplies of some of these necessary elements of fertility are extremely limited when measured by the needs of large crop yields for even one or two generations of people.

THE SUBSURFACE AND SUBSOIL

In Tables 3 and 4 are recorded the amounts of plant food in the subsurface and the subsoil of the different types. It should be remembered, however, that these supplies are of little value unless the top soil is kept rich. These tables also show great stores of potassium in the prevailing types of soil but only limited amounts of nitrogen and phosphorus, in agreement with the data for the corresponding surface samples.

DESCRIPTION OF INDIVIDUAL SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of Iroquois county cover 882 square miles, or 78.5 percent of the area of the county. They usually occupy the less eroded areas of the upland. They are black or brown in color, owing to their high organic-matter content. This land was originally covered with prairie grasses the partially decayed roots of which have been the source of the organic matter. The flat, poorly drained areas contain the greater amounts of organic matter, owing to the more luxuriant growth of the grasses there and to the excessive moisture in the soil which provided conditions better adapted for the preservation of their roots.

Brown Silt Loam (926, 1026, 1126, 1226)

Brown silt loam is the most extensive type in Iroquois county, some townships in the southern part being made up entirely of this type, while others are brown silt loam interspersed with a few very small areas of black clay loam. It covers an area of 681.81 square miles, or practically 60 percent of the area of the county. It is found on land which varies in topography from flat to slightly rolling. The more rolling phase is found in the northwest part of the county and on the moraines in the vicinity of Beaverville in the northeast part.

While this is primarily a prairie type, timber has recently invaded it to a slight extent in some localities. The trees found on the timbered brown silt loam are usually bur oak, wild cherry, black walnut, ash, and elm, but their occupation of the soil has not been sufficiently long to change its character to any great extent.

The surface soil, 0 to $6\frac{2}{3}$ inches, is a brown silt loam varying from a yellowish brown on the more rolling areas to a dark brown or black on the more nearly level and poorly drained tracts. In physical composition it varies to some extent, but it normally contains from 55 to 75 percent of the different grades of silt. In the lower areas the proportion of clay is usually higher than on the more rolling parts, where a perceptible amount of sand may occur. With the flooding of a very large part of the county during the time of the melting of the glacier, more or less sand was carried in and deposited on some of the lower parts, altho much of this has received a deposit of fine silt and clay. Some of the sand was carried to the higher lands by the wind and became mixed with the soil, forming a sandy loam or a sandy phase of the silt loam.

The organic-matter content of the surface soil varies from about 4 to 6 percent, depending on topography, and averages about 5.3 percent, or 53 tons per acre. In small areas on the more rolling parts of the moraines erosion has occurred to such an extent that the type has been changed, but these areas are not large enough to map. In this county the organic-matter content is about the same in amount in the early and the late Wisconsin glaciations.

The natural subsurface is represented by a stratum which varies from 6 to 16 inches in thickness. This variation is due either to erosion, or to the fact that more shallow-rooting grasses usually grew on the higher and better-drained land, or to both of these causes. Erosion removed some of the surface soil from the steeper parts and deposited it on the lower land, thus leaving a thinner layer of the dark soil in one case and producing a thicker one in the other. The physical composition of the subsurface varies in somewhat the same manner as the surface. In some parts, especially on the moraines of the late Wisconsin glaciation, the glacial till constitutes part or all of the subsurface soil.

The organic-matter content is about the same in both glaciations, but varies with topography the same as the surface soil. The average is about 2.6 percent, or 52 tons per acre in a stratum twice the thickness of the surface soil. In color the subsurface varies from a yellowish brown to dark brown or almost black, always changing to a lighter color with increasing depth.

The natural subsoil begins at a depth of 12 to 22 inches and extends to an indefinite depth but is sampled from 20 to 40 inches. It varies from a yellow to a drabbish yellow, silty, clayey material, sometimes composed wholly or in part of boulder clay. This applies especially to the late Wisconsin glaciation. In the flat areas that are not subject to erosion, but where material has been washed in from the higher surrounding land, the subsoil to a depth of 40 inches may not reach the boulder clay.

In general, the three strata of this type are formed from either wind-blown loessial material, boulder clay, or from material deposited in shallow water. A phase of brown silt loam is found on the moraines in the county where, because of the removal of part of the fine loessial material, the glacial drift is encountered at less than 30 inches from the surface. If the drift is quite compact, as is occasionally the case, this gives rise to a subsoil that is somewhat inferior, owing to its less pervious character. This condition, however, does not occur very frequently nor does it include large areas, since most of the glacial drift is pervious and some is even gravelly.

Management.—Originally when the virgin brown silt loam was first cropped, it was in fine tilth, worked easily, and large crops could be grown with much less work than now. Continuous cropping to corn, or to corn and oats, with the burning of corn stalks, stubble, grass, and even straw in many cases, has in a great measure destroyed the tilth, so that now the soil is more difficult to work, washes rather badly, runs together, and bakes more readily than formerly. Unless the moisture conditions are very favorable, the ground will plow up cloddy, with the result that unless well-distributed rains follow, a good seed bed is difficult to produce. The clods may remain all season. Much plant food will be locked up in them, and the best results cannot be obtained. This condition of poor tilth may become serious if the present methods of management continue; in some cases it is already one of the factors that limits crop yields. The remedy is to use a rotation having a clover crop and to increase the organic-matter content by plowing under every available form of vegetable material, such as farm manure, corn stalks, straw, clover, stubble, and even weeds. Fresh organic matter is not only of great value in improving the physical condition of this type of soil, but it is equally important because of its nitrogen content, and also because of its power, as it decays, to liberate potassium from the inexhaustible supply in the soil, and phosphorus from the phosphate contained in or applied to the soil.

The deficiency of organic matter in the soil is shown by the way the fall-plowed land runs together during the winter, or at any time when heavy rains occur. Fall-plowed land should be disked early and deep for the purpose of conserving moisture, raising the temperature, and making plant food available.

For permanent, profitable systems of farming on brown silt loam, phosphorus should be applied liberally, and sufficient organic matter should be provided to furnish the necessary amount of nitrogen. On the ordinary phase of the type limestone is already becoming deficient in the upper strata altho it often exists in considerable quantity in the subsoil. For the permanent improvement of this soil an application of 2 tons of limestone and ½ ton of finely ground rock phosphate per acre about every four years should be made, with the return to the soil of all manure made in a rotation.

Suggestions for practical systems of cropping will be found in the discussion of crop rotations in the Appendix, on page 42. For the results of actual field experiments in improving the soil of the brown silt loam type the reader is referred to page 46 of the Supplement.

Black Clay Loam (920, 1120)

Black clay loam represents the flat prairie land that was formerly swampy. It is sometimes called "gumbo" because of its sticky character. Its occurrence in the flat poorly drained areas is due to the accumulation of organic matter and to the washing in of clay and fine silt from the higher adjoining areas. Aside from a large body of this type found in the northwest part of the county, black clay loam occurs mainly in the south-central part, scattered about in small areas. This type occupies 80.46 square miles, or 7.16 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a black, plastic, granular, clay loam varying locally to a black clayey silt loam, or even to a black sandy clay loam. In physical composition, it varies somewhat as it grades into other types. Often it contains a perceptible amount of sand, and even gravel may be present. In some places that were formerly sloughs the water has deposited gravel in sufficient abundance to form a gravelly black clay loam. The organic-matter content varies from 4.7 to 6.4 percent, with an average of 5.5 percent, or 55 tons per acre.

The natural subsurface stratum has a thickness of 10 to 16 inches. It varies from a black to a brownish drab clay loam and is usually somewhat heavier than the surface soil. It grades into a dull yellow or a drabbish or olive-colored material with depth. The average organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 2.4 percent, or 48 tons per acre. The stratum is usually rather pervious to water, owing to jointing or checking from shrinkage in times of drouth, to the penetration of plant roots, and to the action of crayfish and other animals. Some exceptions to this are found where it grades toward brown-gray silt loam on tight clay (1128) and brown silt loam on tight clay (1128.1). Here the lower strata become somewhat impervious and drainage is slow. These areas occur principally west of the Iroquois river in Townships 27 and 28 North.

The subsoil to a depth of 40 inches varies in composition from a clayey silt to a very heavy clay, and in color from a dull drabbish yellow to drab or olive. Because of poor natural drainage, the iron in the subsoil is not highly oxidized. Concretions of lime carbonate are frequently found. The perviousness of the subsoil is about the same as that of the subsurface and is due to the same causes. When thrown out on the surface where wetting and drying may take place, it soon breaks into small irregular masses about one-fourth to one-half inch square.

The black clay loam presents many variations. It may change with a difference of only a foot or two in elevation. In this county, as elsewhere, the boundary lines between the black clay loam and the brown silt loam are not always distinct. Sometimes on the border between these two types the subsoil is distinctly that of black clay loam, while the surface soil is very silty, or is a good brown silt loam. The washing in of silty material from the surrounding higher lands, especially near the edges of the areas, modifies the character of the soil, giving it a brown silt loam surface. With the annual cultivation of the soil this change is taking place more rapidly now than formerly when washing was largely prevented by prairie grasses. Many small areas of black clay loam in the more rolling parts are being slowly buried by this process.

The areas of heavier subsoil are found in Townships 27 and 28 North, Ranges 10 and 11 East, and 13 and 14 West. This constitutes an old lake floor which was covered with a deposit of very fine material.

Management.—Drainage is the first requirement in the management of this type and, if the outlet is obtainable, this may usually be accomplished with little difficulty. An exception is found west of the Iroquois river in parts of Townships 27 and 28, where drainage is prevented by tight clay subsoil. Thoro drainage helps to keep the soil in good physical condition and is very necessary. After the organic matter is necessarily destroyed by the process of nitrification,

and after the limestone is removed by cropping and leaching, the physical condition of the soil becomes poorer, and as a consequence more difficult to work. Both organic matter and limestone tend to develop granulation and mellowness, which are very essential with heavy soils. The organic matter should be maintained by turning under manure and such crop residues as corn stalks and straw, and by the use of clover and pasture in rotations.

The use of limestone will probably be of little or no value on most of this soil because the subsoil and subsurface are usually naturally charged with carbonates. Because of possible exceptions to this condition, however, it is recommended that the test for the presence of carbonates described in the Appendix, page 37, be made; and if carbonates are not found within a foot of the surface, a moderate application of limestone, say 2 tons per acre, should be made.

For building up this type of soil to its highest state of fertility the phosphorus content ought to be increased. This may be well accomplished by the use of rock phosphate applied at the rate of one-half ton per acre once during each crop rotation.

While the black clay loam is one of the most productive soils in the state, yet its high content of clay and humus imparts a tendency to shrink and expand to such a degree as to be objectionable at times, especially during drouth. The clay and humus expand when the soil is wet, and shrink when the moisture evaporates or is used by the growing crop. This results in the formation of cracks, which are sometimes as much as two or more inches in width at the surface and extend with lessening width to two or three feet in depth. These cracks allow the soil to dry out more rapidly, and as a result the crop is injured thru lack of moisture. They do much damage by ''blocking out'' hills of corn and severing the roots. While cracking may not be prevented entirely, good tilth with a soil mulch will do much toward that end.

Cultivation is more essential on this type, both for aeration and for the conservation of moisture, than on almost any other type in the county. It must be remembered, however, that cultivation should be as shallow as possible in order to prevent injury to the roots of corn. (See Bulletin 181.)

Occasional small patches of alkali soil are found in areas of black clay loam. These spots are indicated by the fact that oats lodge badly and corn makes a poor growth, usually turning yellow or brown. If the amount of alkali is large, the corn may not grow to a height of more than two or three feet and will have a bushy appearance. Even if it reaches almost normal height, it does not produce much grain. The fragments of shells that are frequently found are indications of alkali.

The results of field experiments on black clay loam are given on page 54 of the Supplement.

Brown Sandy Loam (960, 1060, 1160, 1260)

The brown sandy loam of the upland is confined very largely to the northern three-fifths of the county. The southern two tiers of townships contain comparatively small areas, the largest being in the east part along Mud and Sugar creeks. Much the larger area is found in the northeast part of the county north

of Woodland Junction. A low, broad ridge of sandy loam that probably represents the southern shore line of the old lake extends east and west thru Onarga. Another area is found below the Marseilles moraine in the northwest part of the county. This type is very irregularly distributed, being mixed with the brown silt loam, into which it grades. It covers altogether an area of 106.37 square miles, or about 9.5 percent of the area of the county. Its formation is due either to overflow by glacial drainage or to the action of the wind in carrying the sand from the overflow regions to the higher ones. It varies in topography from slightly rolling to flat.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam varying in color from a light brown to a black and in physical composition from a loam with about 50 percent of sand to a very sandy loam carrying 75 percent, or slightly more, of sand. Many small areas of sand are found in this type but they are too small to be shown separately on the map. A representative sample would contain from 60 to 65 percent of sand, mostly of medium grade. The organic-matter content varies from 4.5 to 5.2 percent with an average of 5 percent, or 50 tons per acre.

The natural subsurface stratum varies in thickness from 7 to 12 inches, and in color from dark brown to brownish yellow, usually passing into a yellow sandy silt or silty sand in the lower part of the stratum. In physical composition it varies even more than the surface layer. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 2 percent, or 40 tons per acre in four million pounds.

The subsoil varies both in color and in physical composition. The color may be a bright yellow under conditions of good drainage, or a drabbish yellow where the water table has been rather high. In composition, it may be sand, silt, or clayey silt. As a general rule, the subsoil of the poorly drained areas is heavier than that of the higher and more rolling parts. In some cases the subsoil of the more rolling land may be formed from boulder clay.

Management.—This type in many places needs drainage and, because of the pervious character of the subsoil, this is easily accomplished by tiling. For a sandy loam, the soil is reasonably well supplied with all elements of plant food. Where carbonates are absent, limestone should be used liberally; applications of 2 to 3 tons per acre should be made. A rotation including legumes should be practiced and organic residues should be returned to the soil. Where this is done, sufficient phosphorus and potassium are likely to be liberated for satisfactory results for many years to come, altho ultimately one or both of these elements may need to be supplied—phosphorus first on the more compact phase, and potassium first on the more sandy areas.

Alkali patches occur in considerable numbers, especially on the lower areas which contain the highest percentage of organic matter. The growth of sweet clover is recommended for these areas. One to two hundred pounds per acre of potassium salts may be applied on these alkali spots with good results.

Dune Sand (1081, 1181)

The upland dune sand covers an area of 2,976 acres. Its origin is due almost entirely to the blowing of sand from lower, sandy areas to the upland. The type

occurs principally in a few isolated areas where sandy loam prevails. In topography it varies from flat to rolling with many rounding elevations 20 to 40 feet high.

The surface soil, 0 to 6⅔ inches, varies from a yellow sand to a brownish yellow loamy sand, composed largely of material of medium grade. The soil is low in organic matter, having an average of only about 1.2 percent, or 12 tons per acre in the plowed soil.

The subsurface consists of yellow sand, with about .6 percent of organic matter.

The subsoil is much the same as the subsurface except that its organic-matter content is slightly lower.

Management.—The upland sand dunes should be treated in the same way as those of the terrace (see page 22). These dunes have usually been covered with scattering oak trees, chiefly *Quercus marylandica.*

Brown-Gray Silt Loam on Tight Clay (1128)

Brown-gray silt loam on tight clay occurs almost entirely in Townships 27 and 28 North, Ranges 13 and 14 West. None is found east of the Iroquois river, at least not in areas sufficiently large to be shown on the map. This type is flat in topography, having been formed by deposition from the waters of a shallow lake. A considerable degree of acidity has developed, and this may have aided in the formation of this peculiar type. The area covered by this type is 851 acres.

The surface soil, 0 to 6⅔ inches, is a brown silt loam, but it develops a grayish tint when it becomes dry after a rain. The color of the surface, however, is not uniform; there may be patches of different shades of gray mixed in with the darker soil, giving it a mottled appearance somewhat similar to the scalds of southern Illinois. The organic-matter content is about 3.8 percent, or 38 tons per acre.

The natural subsurface consists of a layer from 7 to 10 inches in thickness which varies from a brown silt loam to a grayish silt or a clayey silt. The upper part of the subsurface is about the same color as the surface soil, or it may be lighter. This is underlain by a grayish stratum varying from 2 to 8 inches in thickness, which is followed by a heavy subsoil.

The subsoil stratum is a heavy, plastic, impervious, yellowish clay that extends to a depth of several feet. It is sometimes underlain by a stratum of sand, but this is so deep that it has little or no effect on drainage.

Management.—Altho this type needs drainage very badly, it is difficult to drain because of the level topography and the impervious subsoil. According to the samples analyzed it is also acid and will require limestone to correct the acidity and to put it into condition for growing clovers to the best advantage. About 2 to 4 tons of limestone per acre is recommended. The phosphorus content is about the same as that of the brown silt loam, and for permanent improvement this element should be supplied. In the management of this soil one very important consideration is the increasing of the organic-matter content. To do this, all forms of crop residues should be turned under, as well as legume crops. Deep-rooting crops should be grown to open up the subsoil.

Brown Silt Loam on Tight Clay (1128.1)

Brown silt loam on tight clay occurs in the same region as brown-gray silt loam on tight clay, but is a slightly better soil because of the absence of the gray stratum in the subsurface and the presence of a more pervious subsoil. This type covers an area of 4,710 acres.

The surface soil, 0 to 6⅔ inches, is a brown silt loam which shows a grayish tint after becoming dry. The color, however, is not uniform, being lighter in some parts than in others. This gives a field the same mottled appearance that is seen in the preceding type. The stratum contains about 4 percent of organic matter, or 40 tons per acre.

The subsurface consists of a brown silt loam which passes into a heavy brownish clayey material at 12 to 15 inches in depth. The stratum sampled (6⅔ to 20 inches) has about 2 percent of organic matter, or 40 tons per acre.

The subsoil consists of a yellowish or drabbish yellow clay, very plastic and tough. It is rather impervious, with the result that drainage does not take place very readily.

Management.—Because the type is usually lacking in limestone in the upper strata, an application of 2 tons per acre of this material is recommended. Drainage is very difficult because of the tight subsoil, and in order to drain it well the lines of tile must necessarily be placed much closer than in the brown silt loam (1126). The requirement as to organic matter is the same as for the preceding type. Deep-rooting crops such as sweet clover will be of great benefit.

(b) UPLAND TIMBER SOILS

The upland timber soils include nearly all the upland areas that are now, or have been, covered with forests. These soils contain much less organic matter than those of the prairie because of the difference in the vegetation that covered them. In forests the vegetable material from trees accumulates upon the surface and is either burned or suffers almost complete decay. Grasses, which furnish large amounts of humus-forming roots, do not grow to any extent because of the shade. Moreover, the organic matter that had accumulated before the timber began growing is removed thru various decomposition processes, with the result that in these soils generally the content of nitrogen and organic-matter has become too low for the best growth of farm crops.

The total area of upland timber soils in the county is 24.40 square miles, or 2.17 percent of the area of the county.

Yellow-Gray Silt Loam (934, 1034, 1134, 1234)

Yellow-gray silt loam is not very extensive in this county, altho it is distributed along most of the courses of the larger streams, where it forms a narrow belt on either side. The area covered by this type is 16.74 square miles, or about 10,000 acres. In topography, it is undulating to slightly rolling and usually has good surface drainage.

The surface soil, 0 to 6⅔ inches, is a gray or yellowish gray silt loam, incoherent and mealy but not granular. In physical composition it varies according to its relation to other types. Where it occurs in the sandy loam areas it

frequently becomes somewhat sandy, and very small areas may contain enough sand to be mapped as sandy loam. White oak and hickory are common trees on this type. The organic-matter content is about 2.1 percent, or 21 tons per acre. The amount increases where the type grades into the brown silt loam which usually borders it.

The natural subsurface stratum varies from 3 to 10 inches in thickness. In color it is gray, grayish yellow, or yellow. It is somewhat pulverulent, but becomes more coherent and plastic with increasing depth. The amount of organic matter of the stratum sampled (6⅔ to 20 inches) is about .7 percent.

The subsoil is a yellow or grayish yellow clayey silt or silty clay, somewhat plastic when wet but pervious to water. Sometimes the subsoil is made up wholly or in part of glacial material. The type as mapped includes some narrow, steep slopes along the bottom lands of streams, that are really yellow silt loam but are too narrow to be shown as such on the map.

Management.—In the management of yellow-gray silt loam, one of the most essential considerations is the maintenance or increase of organic matter. This is much more necessary with the yellow-gray silt loam than with the brown silt loam because of the fact that this soil is naturally much lower in organic matter, having only about two-fifths as much as the brown silt loam. The deficiency of organic matter causes the soil to run together, in the freezing and thawing of winter and in the wetting by the heavy rains of spring and summer. Organic matter will help to prevent washing on the more rolling areas. As it decays, it supplies nitrogen and at the same time tends to liberate other plant-food elements, as explained in the Appendix.

Since the soil is sometimes acid, it is often necessary to apply 2 or 3 tons per acre of ground limestone before the best results can be obtained with legumes. Later applications may be smaller. The growth of legumes is very essential since they furnish organic matter to turn back into the soil and at the same time supply the necessary nitrogen. But all forms of organic matter, such as corn stalks, manure, and weeds are of value and they should be turned into the soil rather than burned. An application of about ½ to 1 ton of rock phosphate per acre should be made about every four years, preferably when the legume or manure is turned under or else preceding the sowing of clover. For the results of field experiments on this type of soil the reader is referred to page 55 of the Supplement.

Yellow-Gray Sandy Loam (1164, 1264)

With only a few exceptions, the yellow-gray sandy loam occurs adjacent to the streams in a manner similar to the yellow-gray silt loam. The type is usually slightly rolling. It covers an area of 2,867 acres.

The surface soil, 0 to 6⅔ inches, is a gray to yellow-gray sandy loam containing about .75 percent of organic matter, or 7.5 tons per acre.

The subsurface is a sandy loam varying in color from yellow to grayish yellow. It contains almost as much organic matter as the surface soil.

The subsoil varies considerably, being made up in some places of a yellowish, sandy, clayey material, while in others it is composed of boulder clay, and in still others, of sand.

Management.—As a type, the yellow-gray sandy loam is somewhat inferior to most other soils of the county. It is low in practically all elements of fertility. In the samples examined carbonates were lacking even in the subsoil. Where such a condition exists 2 to 4 tons of limestone per acre should be applied so that legumes will grow well. The legumes should be turned under to increase the amount of nitrogen which is now much too low for a productive soil. All organic residues should be put back into the soil for the same purpose. The type is low in phosphorus, and ultimately this element must be supplied if the best results are to be obtained in the growth of crops. This element can be built up by the application of about ½ to 1 ton per acre of rock phosphate once in the rotation for two or three rotations, and thereafter a quantity sufficient to replace what is removed by crops.

Yellow Silt Loam (1135)

Yellow silt loam is found on steep slopes along the streams, and its origin is due to erosion. It covers an area of 1,011 acres.

The surface soil, 0 to 6⅔ inches, consists of a yellow to brownish yellow silt loam varying in composition from a sandy material on the one hand to a rather heavy phase on the other. The surface stratum contains about 2.4 percent of organic matter, or 24 tons per acre.

The subsurface is a yellow silty or sandy material varying toward a silty clay. The stratum contains about one percent of organic matter.

The subsoil is a yellow clayey silt and in many cases is formed from boulder clay.

The type is usually not under cultivation and can be used only for pasture.

Yellow-Gray Silt Loam on Tight Clay (1138)

Yellow-gray silt loam on tight clay occurs only in Township 27 North, Range 13 West. It covers only 1,024 acres.

The surface soil, 0 to 6⅔ inches, is a gray or yellowish gray silt loam containing about 2.9 percent of organic matter, or 29 tons per acre.

The subsurface is a grayish yellow silt loam passing into a heavy impervious stratum at about 15 to 17 inches. It contains 1.3 percent of organic matter or 26 tons per acre in four million pounds of soil.

The subsoil is a stiff, impervious clay, varying from yellow to drabbish yellow in color.

Management.—The greatest needs of this type are limestone and legume crops. The subsurface is usually quite acid, altho the subsoil in some places contains a small amount of limestone. Fortunately this very poor type of soil covers but a small area.

(c) TERRACE SOILS

The terrace soils of Iroquois county are formed in two ways: first, as gravel outwash plains from the melting glacier; and second, as gravel fills in stream valleys. The extensive areas along Beaver creek and in the vicinity of Pittwood, also south and east of Crescent, are of the former formation while those along

Sugar creek and the Iroquois river are of the latter. The depth to the gravel and sand varies to some extent, being from 24 inches to five feet or more. On account of the high water table resulting from the shallow cuts of streams the terrace types in this county are not easily drained.

The total area of all the terrace types in Iroquois county is 167.49 square miles, or nearly 15 percent of the area of the county.

Brown Sandy Loam (1560)

The brown sandy loam of the terrace, is one of the most common types in Iroquois county. It covers 108.30 square miles, or nearly 10 percent of the area of the county. It does not differ very much in composition from the upland sandy loam.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam varying in color from black to light brown, and in composition from a loam to a sand. A representative sample, however, will contain about 65 to 70 percent of sand. The organic-matter content varies from 3 to 8 percent, with an average of about 5.1 percent, which is equivalent to 51 tons per acre.

The natural subsurface consists of a sandy loam layer varying in thickness from 6 to 12 inches and in color from black to brownish or yellowish. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 1.7 percent, or 34 tons per acre.

The subsoil is a yellow to drabbish yellow clayey sand varying to a sandy clay, and is readily pervious to both air and water. Limestone is sometimes found in the subsoil.

Management.—The analysis of samples taken from different locations show great variation with respect to the limestone requirement. In some localities carbonates are abundant in all strata analysed, while in other places these are absent in all strata. In this situation, therefore, it is especially necessary to apply the tests for acidity and carbonates described on page 37 of the Appendix. If carbonates are not present within a foot of the surface, this fact may be taken as a sure indication that limestone is needed for the thrifty growth of legumes; it should be applied at the rate of 2 to 4 tons per acre. Phosphorus fertilizer is not so necessary on this kind of soil as on the brown silt loam, owing to the fact that on this type the roots of plants are distributed to a greater extent thru the soil and to a greater depth than in the brown silt loam. However, this element is becoming somewhat low and in some instances applications may be profitable, especially after the stock of nitrogen is well built up.

Brown Silt Loam (1526)

Brown silt loam occurs as rather isolated areas in the terraces and covers only 2.66 square miles, or 1,702 acres.

The surface soil, 0 to 6⅔ inches, contains approximately the same percentage of organic matter as the upland brown silt loam. In physical composition it varies to a considerable extent according to the surrounding soil types, and often grades into a sandy loam.

The natural subsurface is represented by a stratum 7 to 11 inches in thickness. It is a brown silt loam which changes to yellow with increasing depth.

The subsoil is a yellow sandy silt or sandy clay varying to a yellow sand. It is easily permeated by water and air.

Management.—The type requires the same treatment as the upland brown silt loam (see page 10).

Brown Silt Loam over Gravel (1527)

Brown silt loam over gravel is found principally along the streams and constitutes a part of the true stream terrace. It covers an area of 13.20 square miles, or 8,448 acres.

The surface soil, 0 to 6⅔ inches, is a little lighter in color than the upland brown silt loam. It varies somewhat in composition, being distinctly sandy in some places. It contains about 4.4 percent of organic matter, or 44 tons per acre.

The natural subsurface comprizes a silt loam stratum varying from 6 to 12 inches in thickness. It varies in color from brown to light brown. The stratum sampled (6⅔ to 20 inches) contains about 2.1 percent of organic matter, or 42 tons per acre.

The subsoil varies from a yellow silt to a yellow sandy silt. In some instances gravel is found at a depth of 36 to 48 inches. This provides good drainage where the water table is lowered sufficiently.

Management.—In the samples examined the lower strata of this type were acid. In cases where this is the condition, 2 or 3 tons of limestone per acre will be required as an initial application to correct the acidity and thus provide favorable conditions for the growth of legumes. About half the amount of this initial application should be applied every four years thereafter, or until the most favorable conditions for the growth of legumes are established. The same need for turning under legumes and organic residues exists in this type as in other brown silt loam types of the county.

Yellow-Gray Sandy Loam (1564)

Yellow-gray sandy loam is found very largely along the streams, altho an occasional small area may form an exception to this. It is associated with the yellow-gray silt loam in that it occurs in similar situations and that it has been covered by forests. The total area occupied by this type is 5,850 acres.

The surface soil, 0 to 6⅔ inches, is a brownish gray or brownish yellow sandy loam varying in physical composition in the same way as the other sandy loams of the county. The organic-matter content is about 2.5 percent, or 25 tons per acre.

The subsurface is a yellow sandy loam varying to a sandy silt loam and even to a sand. It contains about .5 percent of organic matter.

The subsoil consists of a yellow sandy silt that extends into gravel, in some instances at a depth of 36 to 40 inches. It contains about .45 percent of organic matter.

Management.—According to the samples tested this type is strongly acid, and an initial application of about 4 tons of limestone per acre should be made. This should be followed with about 2 tons every four years until the soil is brought into condition for the best growth of legumes. Organic matter, especially

legumes, must be turned under to bring about conditions of good tilth in the soil and to increase the supply of nitrogen, which analysis shows to be extremely low. The phosphorus content is likewise extremely low and ought to be built up before it becomes a limiting element.

Dune Sand (1581)

Dune sand on the terrace consists of rather small, irregular, isolated areas, all of them together covering 18.5 square miles, or 1.65 percent of the area of the county. These dunes have been formed of sand deposited as sand bars by the streams that once covered these regions. Later this sand was reworked by the wind, which piled it up into dunes ranging from a few feet to 25 or 30 feet in height.

The surface soil, 0 to 6⅔ inches, varies from a brownish yellow, slightly loamy sand to a yellow sand. It contains about 1.2 percent of organic matter, or 12 tons per acre. The sand is usually of medium texture and is comparatively free from the finer constituents.

The subsurface consists of a layer composed very largely of yellow sand, altho on the more loamy phases there may be enough organic matter to give the top of this stratum a brownish tint. It contains about .6 percent of organic matter.

The subsoil is a yellow sand with about .4 percent of organic matter.

Management.—This dune sand contains no limestone, either in the surface, subsurface, or subsoil, and it is exceedingly poor in nitrogen. Altho the total supply of potassium is large, this element is likely to be locked up to a considerable extent in sand grains and consequently is not susceptible of liberation by practical means altho sufficient amounts can usually be made available for very good crops. (On swamp sands and sandy loams long exposed to leaching, potassium is often the first limiting element, especially where a fair supply of humus exists, as in the so-called "black sand.")

The phosphorus content of sand soils is not high, but this element exists to a considerable extent in other constituents than sand grains. The United States Bureau of Soils separated two types of sandy soil—glacial sand and sandy loam—into coarse, medium, and fine particles, analyzed each grade for phosphorus, and found that as an average of the two soils the fine portion was eighteen times as rich in the element phosphorus as the coarse. Under successful cropping, such a limited amount of phosphorus as this dune sand contains would, however, sooner or later become exhausted, altho field experiments might not indicate a need for this element at first.

In the management of this type, the two things of first and by far the greatest importance are the addition of limestone and of organic matter. While this sand soil is not high in acidity, the samples examined were entirely devoid of limestone to a depth of more than 40 inches. For satisfactory results, therefore, an initial application of 3 to 4 tons per acre should be made, and this supply should be maintained by subsequent applications of about 2 tons every four or five years, or until conditions are established for the best growth of legumes.

Organic matter is needed to increase the moisture-retaining power, to furnish nitrogen, and to prevent blowing. Sand possesses very little cohesion, and is therefore readily moved by the wind. In fact, wind erosion on this soil is worse than water erosion on other soils, and unless some special means are used, especially on the more sandy areas, to prevent the movement by wind action, ultimate ruin of the soil will result. When organic matter is added, it acts as a feeble cement which, however, is sufficiently strong to bind the soil particles together and prevent blowing. In a test at this Station, the moisture-holding capacity of clean medium sand was increased 40 percent by the addition of 5 percent of peat, and 85.7 percent by the addition of 10 percent of peat.

When potash salts can be secured at reasonable cost, their use is likely to produce profitable results, at least temporarily, in getting under way systems of permanent improvement on this soil. This applies more especially to the level areas which were originally sandy swamps.

Corn on sand land ''fires'' very badly; that is, the lower leaves dry up. This is partly due to the fact that the soil is low in the element nitrogen and there is a translocation of the nitrogen from the lower to the upper leaves in order to continue growth. This drying up, which is usually attributed to lack of moisture, can be largely prevented by the presence of plenty of available nitrogen. The fact should be remembered that less moisture is required to produce a crop on a soil plentifully supplied with plant food than to produce one on a poor soil.

Rye is one of the hardy non-legumes often grown on sand soil, but this crop does not sufficiently cover the soil to protect it from blowing. Furthermore, it is a common practice to sell the straw as well as the grain, and this leaves very little organic matter to be turned back into the soil. A practice that could be followed to good advantage in favorable seasons would be to sow cowpeas after the rye, following the binder with the drill, and then later drilling rye in the cowpeas without cutting them or turning them under. This would serve to protect the soil from blowing as well as to furnish a supply of nitrogen and organic matter, and the practice would undoubtedly result in the improvement of this loose sandy type.

Cowpeas are well adapted to such soil, and they produce very large yields of excellent hay or grain very valuable for feed and seed. Under the best conditions and with good preparation, sweet clover can be grown in good seasons with proper soil treatment. With an abundance of limestone and moderate manuring, alfalfa can also be grown. More than five tons of alfalfa hay per acre in one year has been produced on an experiment field at Green Valley and similar results have been obtained on the Oquawka field. Sweet clover and alfalfa should be inoculated with the proper nitrogen-fixing bacteria.

Other possibilities of this type of soil may be shown by the use to which it is put in the vicinity of Wichert, where truck farming is carried on extensively. Where heavily manured, this dune sand has become very valuable for growing asparagus and other crops.

Foresting is a practical way of conserving these sand soils. The black locust (a leguminous tree) seems to do exceptionally well on sand. One difficulty with this tree, however, is that it is damaged by borers; but if it is used to start a

growth and hold the sand, other trees may then be interplanted and the result will be that the sand will be held permanently. After the blowing of sand is once stopped, very careful treatment is required to prevent a recurrence of the trouble. Pasturing should be done very carefully, because the grass is easily destroyed.

For an account of field experiments on dune sand see page 58 of the Supplement.

Yellow-Gray Silt Loam (1534)

Yellow-gray silt loam occurs in small areas along streams, particularly along the Iroquois river. It is very little different from the following type, yellow-gray silt loam over gravel, except that it appears to be of a later formation and the gravel does not occur.

The surface soil, 0 to 6⅔ inches, is a yellowish gray or yellowish brown silt loam with an organic-matter content of about 2.9 percent, or 29 tons per acre.

The subsurface is a yellowish or brownish yellow silt loam.

The subsoil is a yellow silt, in some places becoming rather heavy while in other places it is friable.

Management.—The treatment of this type should be the same as that of the yellow-gray silt loam over gravel (1536).

Yellow-Gray Silt Loam over Gravel (1536)

Yellow-gray silt loam over gravel occurs principally along the Iroquois river and Sugar creek, and is usually 25 to 30 feet above the bottom land. It covers an area of 6.37 square miles, or 4,077 acres.

The surface soil, 0 to 6⅔ inches, is a yellowish or grayish yellow silt loam, varying in sand content to a loam and in some places even to a sandy loam. The organic-matter content ranges from 1.8 to 3 percent, and averages 2.4 percent, or 24 tons per acre.

The subsurface is a yellow silt loam containing .8 percent of organic matter, or about 16 tons per acre.

The subsoil is a yellow silty material underlain by gravel, which in some places is less than 40 inches beneath the surface. It contains about .4 percent of organic matter.

Management.—In the management of this type, one of the first requirements is an application of 2 to 3 tons of limestone per acre to correct the acidity which in the subsoil becomes very high. The low content of organic matter indicates that it would be desirable to turn under all residues possible. Legumes should be grown and the best use made of straw, residues, and manure. Along with the improvement in this way, it would be of benefit to apply from ½ to 1 ton of rock phosphate per acre once in the rotation until the phosphorus content is well built up in the soil. This would be a good soil for alfalfa, as it is generally well drained, owing to the underlying stratum of gravel.

Brown Sandy Loam over Gravel (1566)

Brown sandy loam over gravel occurs along the Iroquois river and Sugar creek, and is formed in the same way as the preceding type (1536). It includes a total area of 3,187 acres.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam varying on the one hand to brown silt loam, and on the other to sand. It contains about 2.9 percent of organic matter, or 29 tons per acre.

The subsurface is a brown sandy loam, passing into a yellowish sandy silt at a depth of about 15 inches. It contains about 1.6 percent of organic matter.

The subsoil is a yellow sandy silt varying to a silt. The gravel is sometimes found at a depth of less than 40 inches altho it usually occurs at greater depths.

Management.—In the samples examined the subsurface and subsoil strata were acid. Where this condition occurs it will be necessary to apply 2 or 3 tons of limestone per acre to secure the best results with legumes. The same use must be made of organic residues and manure as that indicated for the preceding type. Applications of phosphorus will aid in giving satisfactory results, both for legumes and for grain crops.

Yellow-Gray Sandy Loam over Gravel (1567)

Yellow-gray sandy loam over gravel occurs along the streams in a manner similar to that of the preceding type, but it has been timbered sufficiently long to reduce the organic matter to a very small amount. It covers an area of 3.30 square miles, or 2,112 acres.

The surface soil, 0 to 6⅔ inches, is a gray to light yellow sandy loam. It ranges in texture from a loam to a very sandy phase of sandy loam. It contains about 1.8 percent of organic matter, or 18 tons per acre.

The subsurface soil is a gray or yellowish gray sandy loam, passing into the heavier phase characteristic of the subsoil at a depth of about 15 to 17 inches.

The subsoil consists usually of a sandy clayey material that is underlain by gravel at a depth of 36 to 54 inches.

Management.—This type is very low in nitrogen, containing only 1,420 pounds per acre in the plowed soil. Legumes must be grown in order to increase the nitrogen content. Since the soil is very acid, it is necessary to apply 3 to 4 tons of limestone per acre to produce the best growth of legumes. All available organic residues and farmyard manure must be turned under in order to increase and maintain the supply of organic matter and nitrogen. This soil is also very low in phosphorus, and this element should be added.

Brown Silt Loam on Gravel (1526.4)

Brown silt loam on gravel occurs to a limited extent along Sugar creek in the vicinity of Woodland Junction. It covers only 211 acres.

The surface soil, 0 to 6⅔ inches, is lighter in color than the upland brown silt loam. It contains about 3 percent of organic matter.

The subsurface soil is a yellowish brown or brownish yellow silt loam.

The subsoil is a yellow sandy or gravelly silt loam passing into gravel at a depth of about 26 to 32 inches.

Management.—This type requires the same treatment as brown silt loam over gravel (1527) (see page 21). The gravel subsoil gives good drainage.

Black Clay Loam (1520)

Black clay loam of the terrace does not differ much from the upland black clay loam; hence the treatment that it should receive is practically the same. The reader is therefore referred to the discussion of black clay loam on page 13.

(d) SWAMP AND BOTTOM-LAND SOILS

This group includes the bottom lands along the streams, the swamps, and the poorly drained lowlands. Much of the soil, therefore, is of alluvial formation and the land is largely subject to overflow. The swamps were formerly what their name implies, but during the wettest part of the year at least they were shallow ponds or lakes. Seven types of this group are recognized in Iroquois county, the total area of which aggregates 48.76 square miles, or about 4.5 percent of the area of the county.

Deep Brown Silt Loam (1426)

Deep brown silt loam constitutes the larger part of the bottom land along the streams. Altho it varies slightly in some places, especially toward the northern part of the county, yet generally it consists of a brown silt loam, the dark color of which extends to a depth of 20 to 30 inches. It covers an area of 29.06 square miles, or 2.59 percent of the area of the county. At one time the terrace constituted the overflow land of the streams of the county, but later the streams cut below this terrace and began to develop a new flood plain that is the present first bottom land.

The surface soil, 0 to 6⅔ inches, is a brown silt loam containing from 5 to 7 percent of organic matter, or an average of 6 percent. The surface soil varies somewhat, owing to the deposition of sand in times of overflow.

The subsurface soil, 6⅔ to 20 inches, consists of a brown silt loam containing more or less sand. The organic-matter content is about 5.1 percent.

The subsoil varies from a brown silt loam to a yellowish or brownish yellow silt loam, and contains about 2.4 percent of organic matter.

Management.—This type contains a good supply of organic matter and nitrogen and has a phosphorus content varying from 1,200 to 1,600 pounds per acre in the plowed soil. The soil is usually either neutral or slightly acid, altho not so acid but that legumes will do well upon it. During times of overflow the type receives a deposit of rich soil. Therefore the most important requirement in its management is good cultivation. Large numbers of weed seed are deposited during flood times, and these are frequently a source of much trouble.

Mixed Loam (1454)

Mixed loam occurs principally as bottom land along Beaver creek in the northeastern part of the county. So much sand is carried into this stream that the bottom-land soil is badly mixed and it is therefore practically impossible to separate it into distinct types. Even if this could be done, the next flood would probably change the character of the soil. The area covered by this type amounts to 2,483 acres.

The surface soil, 0 to 6⅔ inches, is a mixed loam varying from a sand to a silt loam. It contains about 6.6 percent of organic matter.

The subsurface soil, 6⅔ to 20 inches, is a brown mixed loam with about 1.43 percent of organic matter.

The subsoil varies in somewhat the same way as the surface and is usually of a yellowish or brownish yellow color.

The type is of little importance so far as agriculture is concerned. It is used mainly for pasture.

Black Sandy Loam (1461)

Black sandy loam occurs in several isolated areas, the largest being in the northwest part of the county just south of the Marseilles moraine. This type covers an area of 12.61 square miles.

The surface soil, 0 to 6⅔ inches, is a black sandy loam varying on the one hand to a clayey sandy loam and on the other to a peaty loam. It contains about 5.3 percent of organic matter, or 53 tons per acre.

The natural subsurface consists of a stratum 8 to 12 inches thick, and varies from a brown to a yellowish brown sandy loam. This stratum usually contains sufficient amounts of the finer constituents, either clay or fine silt, to give it some tenacity. The organic-matter content of the stratum sampled is about 1.6 percent, or 32 tons per acre.

The subsoil consists of a pale yellow to grayish colored sandy clay or clayey sand and contains about .5 percent of organic matter.

Management.—The type needs drainage first, and while most areas have been drained, yet in some localities much more is needed. An occasional legume crop is desirable to aid in keeping the soil in good physical condition and in maintaining the nitrogen content. Where carbonates are absent, limestone should be applied in order to provide the most favorable conditions for the growth of legumes.

Peaty Loam on Sand (1410.2)

Peaty loam on sand covers only a small area, amounting to 288 acres.

The surface soil is a peaty loam consisting of organic matter and sand. The organic-matter content is about 19.8 percent, or 148.5 tons per acre.

The subsurface contains a little more than half the amount of organic matter that is found in the surface.

The subsoil is a gray or drab sand with only .8 percent of organic matter.

Management.—Proper drainage is of course essential in the successful cultivation of this kind of soil. Experience on soil of a similar nature has shown good returns from the use of manure and of potassium sulfate.

Deep Peat (1401)

Deep peat is found in small areas on both upland and terraces and covers 1,139 acres, or .16 percent of the area of the county. The soil to a depth of at least 30 inches consists largely of organic matter derived from mosses, sedges, and grasses.

The surface soil, 0 to 6⅔ inches, consists of a black or brownish peat, more or less decomposed. As a general rule, the drained areas have undergone greater decomposition because of better aeration, while the undrained areas have changed but little. The content of organic matter is about 59 percent, or 295 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a black or brownish peat that usually shows the texture of the material from which it was produced. The organic-matter content is about 31 percent.

The subsoil, 20 to 40 inches, is usually a brown peat, altho in small areas, sand, silt, or clay of a drab color may constitute the subsoil below 30 inches. The organic-matter content varies widely. The line between the peat and the mineral subsoil is usually very distinct.

Management.—Because of lack of drainage, this type of soil in Iroquois county has not been cultivated to a large extent. It is used mostly for pasture, and probably this is the best use to which it can be put. Tile drainage is not usually satisfactory because the soft peat soon permits the tile to get out of line and this seriously interferes with drainage.

Where thoro drainage can be provided either by open ditches or by laying tiles deep enough to secure a solid bed for them, very marked improvement can be made in the productive power of deep peat by the liberal use of potassium, which is by far the most deficient element. These soils frequently contain alkali that irritates the skin. The term "itch dirt" is often applied to them.

In the Supplement to this report are given the results obtained from field experiments on deep peat (see page 60).

Medium Peat on Clay (1402)

Medium peat on clay consists of a soil in which the peat is more than 12 and less than 30 inches in depth. Typically it is underlain by clay or silty clay, altho in some locations sand may occur instead of clay. This soil originates in the same way as deep peat. The total area in the county is 467 acres.

The surface soil, 0 to 6⅔ inches, is a brown or black peat, which may contain some sand. If the sand content becomes very high, the type passes into the peaty loam, a small area of which borders it on the south. The organic-matter content is about 36 percent.

The subsurface varies widely even in the same locality. The organic matter or peat may form a part of the subsurface or the entire stratum. The organic-matter content is approximately 9.8 percent.

The subsoil may be formed in part of peat. The mineral part consists of clay and sand but is distributed so irregularly that it is impossible to separate the areas into the two types. The clay subsoil seems to be the more prevalent. The organic-matter content is about 2.6 percent.

Management.—Drainage is one of the principal considerations in the management of the type. It may usually be provided without much difficulty because the clay affords a good bed for tile. The treatment for this type is likely to be the same as for deep peat, but thoro trials should be made with potassium in

advance of extensive use, for the surface and subsurface strata sometimes have sufficient potassium contained in the mineral particles deposited from repeated overflow.

Clayey Muck (1413)

Clayey muck is found in the northwestern part of the county in a few areas just south of the morainal ridge. These areas cover 160 acres.

The surface soil consists of a black, granular, plastic, clayey material having about 17.5 percent of organic matter.

The subsurface is very similar to the surface except that in its lower depths its assumes a slightly more drabbish color. It contains about 19 percent of organic matter.

The subsoil usually consists of a black to drabbish clay, waxy, but pervious to water. The sample collected contained about 10 percent of organic matter.

Management.—The upper strata of this soil contain no limestone but carbonates are found in the subsoil. Drainage is the first requirement, and after that good cultivation is about all that is necessary. The supply of potassium is abundant, as is also that of phosphorus, clayey muck being one of the richest soils of the county in this constituent. The rotation of crops is necessary in order to control insects and weeds.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to intelligently interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification here used.

The unit in the soil survey is the soil type, and each type possesses more or less definite characteristics. The line of separation between adjoining types is usually distinct, altho sometimes one type grades into another so gradually that it is very difficult to draw the line between them. In such exceptional cases, some slight variation in the location of soil-type boundaries is unavoidable.

In establishing soil types several factors must be taken into account. These are: (1) the geological origin of the soil, whether residual, cumulose, glacial, eolial, alluvial, or colluvial; (2) the topography, or lay of the land; (3) the native vegetation, as forest or prairie grasses; (4) the depth and the character of the surface, the subsurface, and the subsoil, as to the percentages of gravel, sand, silt, clay, and organic matter which they contain, their porosity, granulation, friability, plasticity, color, etc.; (5) the natural drainage; (6) the agricultural value, based upon its natural productiveness; (7) the ultimate chemical composition and reaction.

Great Soil Areas in Illinois.—On the basis of the first of the above mentioned factors, namely, the geological origin, the state of Illinois has been divided into sixteen great soil areas with respect to their geological formation. The names of these areas are given in the following list along with their corresponding index numbers, the use of which is explained below. For the location of these geological areas, the reader is referred to the general map published in Bulletins 123 and 193.

100 *Unglaciated,* comprizing three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciation
300 *Lower Illinoisan glaciation,* covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river bottom and swamp lands,* found in the older or Illinoisan glaciation
1400 *Late river bottom and swamp lands,* those of the Wisconsin and Iowan glaciations
1500 *Terraces,* formed by overloaded streams draining from the glaciers and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago or the enlarged Lake Michigan

Mechanical Composition of Soils.—The mechanical composition, or the texture, is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents:

Organic matter: undecomposed and partially decayed vegetable material

Inorganic matter: clay, silt, fine sand, sand, gravel, stones.

Classes of Soils.—Based upon the relative proportion of the various constituents mentioned above, soils may be grouped into a number of well recognized classes. Following is a list of these classes, arranged according to their index numbers, the use of which is explained below.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

Naming and Numbering Soil Types.—The naming of soil types has been the subject of much discussion, and practice varies considerably in this matter. In this soil survey of Illinois a system of classification and naming has been adopted which is based upon the various considerations presented in the preceding paragraphs.

After texture, one of the most striking characteristics of a soil is the color. Therefore, in the naming of soils in Illinois, a combination of color and texture, together with other descriptive terms when necessary, has been adopted so that the name in itself carries a definite description of a given soil type; as for example, "gray silt loam on tight clay," or "brown silt loam over gravel." The use of the prepositions *on* and *over* serves to indicate the presence of certain substrata. When the surface soil is underlain with material such as sand, gravel, or rock, the word *over* is used if this material lies at a depth greater than 30 inches; if it is less than 30 inches, the word *on* is used.

For further identification of soil types a system of numbering, resembling somewhat the Dewey library system, has been adopted whereby each soil type is assigned a certain number. This number indicates at once the geological origin of the soil as well as its physical description. The digits of the order of hundreds represent the geological area where the soil is found, beginning at 100 with the unglaciated, and following in series in the order of the enumeration presented in the paragraph above headed *Great Soil Areas In Illinois.* The digits of the orders of units and tens represent the various kinds of soil such as are enumerated above in the list of soil classes. A modification of a soil type called a *phase* is designated in this system by a figure placed at the right of the decimal point. To illustrate the working of this numbering system, suppose a soil type bears the number 726.5. The number 7 indicates that this soil occurs in the Iowan glaciation, the 26 that it is a brown silt loam, and the .5 that rock is found less than 30 inches below the surface. These numbers are especially useful in designating small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and a description of the area covered, will be found in the respective county soil reports.

SOIL SURVEY METHODS

Mapping the Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. In order that the survey be thoroly truthworthy it is necessary that careful, well-trained men be employed to do the mapping. The work is prosecuted to the best advantage by working in parties of from two to four. Only such men are placed in charge of these parties as are thoroly experienced in the work and have shown themselves to be especially well qualified in training and ability.

The men must be able to keep their location exactly and to recognize the different soil types, with their principal variations and limits, and they must show these upon the maps correctly. A definite system is employed in checking up this work. As an illustration, one man will survey and map a strip 80 rods or 160 rods wide and any convenient length, while his associate will work independently on another strip adjoining this area, and if the work is correctly done the soil-type boundaries will match up on the line between the two strips.

An accurate base map for field use is absolutely necessary for soil mapping. The base maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as a basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil-type boundaries, together with the streams, roads, railroads, canals, and town sites are placed in their proper locations upon the map while the mapper is on the area. Each section, or square mile, is divided into 40-acre plots on the map, and the surveyor must inspect every ten acres and determine the type or types of soil composing it. The different types are indicated on the map by different colors, pencils for this purpose being carried in the field.

A small auger 40 inches long forms for each man an invaluable tool with which he can quickly secure samples of the different strata for inspection. An extension for making the auger 80 inches long is taken by each party, so that any peculiarity of the deeper subsoil layers may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by an odometer attached to the axle of the vehicle or by some other measuring device, while distances in the field away from the roads are determined by pacing, an art in which the men become expert by practice. The soil boundaries can thus be located with as high a degree of accuracy as can be indicated by pencil on the scale of one inch to the mile.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. For this purpose usually three strata are sampled; namely, the surface (0 to 6⅔ inches), the subsurface (6⅔ to 20 inches), and the subsoil (20 to 40 inches). These strata correspond approximately, in the common kinds of soil, to 2,000,000 pounds of dry soil per acre in the surface layer, and to two times and three times this quantity in the subsurface and the subsoil, respectively.

By this system of sampling we have represented separately three zones for plant feeding. The surface layer includes at least as much soil as is ordinarily turned with the plow. This is the part with which the farm manure, limestone, phosphate, or other fertilizer applied in soil improvement is incorporated, and which must be depended upon in large part to furnish the necessary plant food for the production of crops. Even a rich subsoil has little or no value if it lies beneath a worn-out surface, but if the fertility of the surface soil is maintained at a high point, then the strong, vigorous plants will have power to secure more plant food from the subsurface and subsoil.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. Even tho plowed alike and at the same time, prepared the same way, planted the same day with the same kind of seed, and cultivated alike, watered by the same rains and warmed by the same sun, nevertheless the best acre may produce twice as large a crop as the poorest acre on the same farm, if not, indeed, in the same field; and the fact should be repeated and emphasized that with the normal rainfall of Illinois the productive power of the land depends primarily upon the stock of plant food contained in the soil and upon the rate at which it is liberated, just as the success of the merchant depends primarily upon his stock of goods and the rapidity of sales. In both cases the stock of any commodity must be increased or renewed whenever the supply of such commodity becomes so depleted as to limit the success of the business, whether on the farm or in the store.

CROP REQUIREMENTS

Ten different elements of plant food are essential for the growth and formation of every plant. These elements are: *carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, magnesium, calcium, and iron;* and they are represented by the chemical symbols: C, O, H, N, P, S, K, Mg, Ca, and Fe. Some seasons in central Illinois are sufficiently favorable to allow the production of at least 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. When such crops are not produced under favorable seasonal conditions, the failure is due to unfavorable soil condition, which may

TABLE A.—PLANT FOOD IN WHEAT, CORN, OATS, AND CLOVER

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain......	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat, straw.....	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain.......	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover.......	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs........	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain.......	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw........	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed.......	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay.......	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00

result from poor drainage, poor physical condition, or an actual deficiency of plant food.

Table A shows the plant-food requirements of some of our most common field crops with respect to the seven elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of any element removed from an acre of land by a crop of a given yield can easily be computed.

It needs no argument to show that the continuous removal of such quantities of plant food without provision for their replacement must result sooner or later in soil depletion.

PLANT-FOOD SUPPLY

Of the ten elements of plant food, three *(carbon, oxygen,* and *hydrogen)* are secured from air and water, and seven from the soil. *Nitrogen,* one of these seven elements obtained from the soil by all plants, may also be secured from the air by one class of plants (legumes), in case the amount liberated from the soil is insufficient; but even these plants (which include only the clovers, peas, beans, and vetches among our common agricultural plants) are dependent upon the soil for the other six elements *(phosphorus, potassium, magnesium, calcium, iron, and sulfur*), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

TABLE B.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	19
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[1]	80	8	28
Dried blood	280	...	...
Sodium nitrate	310	...	...
Ammonium sulfate	400	...	...
Raw bone meal	80	180	...
Steamed bone meal	20	250	...
Raw rock phosphate	...	250	...
Acid phosphate	...	125	...
Potassium chlorid	...	...	850
Potassium sulfate	...	...	850
Kainit	...	...	200
Wood ashes[2]	...	10	100

[1]Young second year's growth ready to plow under as green manure.
[2]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

The vast difference with respect to the supply of these essential plant food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to nearly 33,000 pounds. In like manner the phosphorus content varies from about 420 pounds to 4,900 pounds, the potassium ranges from 1,530 pounds to about 58,000 pounds. Similar variations are found in all of the other essential plant food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table B is presented for the purpose of furnishing information regarding the quantity of plant food contained in some of the materials most commonly used as sources of plant-food supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of fertility actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are limestone and decaying organic matter. Tillage also has a considerable effect in this connection.

Effect of Limestone.—Limestone corrects the acidity of the soil and thus encourages the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the insoluble and unavailable organic nitrogen into soluble and available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium, and also to dissolve the insoluble phosphate and limestone which may be applied in low-priced forms. Thus, in the conversion of sufficient organic nirogen into nitrate nitrogen for a 100-bushel crop of corn, the nitrous acid formed is alone sufficient to convert seven times as much insoluble tricalcium phosphate into soluble monocalcium phosphate as would be required to supply the phosphorus for the same crop.

Effect of Organic Matter.—Organic matter may be supplied by animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter, and by plant manures, including green-manure crops and cover crops plowed under and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant food than the 20 tons of old, inactive organic matter. The history of the individual

farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated more or less definitely by the *ratio of carbon to nitrogen.* As an average, the fresh organic matter incorporated with soils contains about twenty times as much carbon as nitrogen, but the carbohydrates ferment and decompose much more rapidly than the nitrogenous matter; and the old resistant organic residues, such as are found in normal subsoils, commonly contain only five or six times as much carbon as nitrogen. Soils of normal physical composition, such as loam, clay loam, silt loam, and fine sandy loam, when in good productive condition, contain about twelve to fourteen times as much carbon as nitrogen in the surface soil; while in old, worn soils that are greatly in need of fresh, active, organic manures, the ratio is narrower, sometimes falling below ten of carbon to one or nitrogen. Except in newly made alluvial soils, the ratio is usually narrower in the subsurface and subsoil than in the surface stratum. Soils of cut-over or burnt-over timber lands sometimes contain so much partially decayed wood or charcoal as to destroy the value of the nitrogen-carbon ratio for the purpose indicated.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing soluble phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant food by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant food is concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes: Limestone provides the plant food calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much

more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by preventing the growth of certain fungus diseases, such as corn root rot. Experience indicates that it modifies directly the physical structure of some soils, frequently to their great improvement.

Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands. Remarkable success has been experienced with limestone used in conjunction with sweet clover in the reclamation of abandoned hill land which had been ruined thru erosion.

Amounts to Apply.—If the soil is acid, at least 2 tons per acre of ground limestone should be applied as an initial treatment. Continue to apply limestone from time to time according to the requirement of the soil as indicated by the tests described below, or until the most favorable conditions are established for the growth of legumes, using preferably at times magnesian limestone ($CaCO_3MgCO_3$), which contains both calcium and magnesium and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone ($CaCO_3$). On strongly acid soils, or on land being prepared for alfalfa, 4 or 5 tons per acre of ground limestone may well be used for the first application.

How to Ascertain the Need for Limestone.—The need of a soil for limestone may be ascertained by applying one of the following tests for soil acidity. Along with the acidity test, a test for the presence of carbonates should be made. It should be understood that a positive test for carbonates does not guarantee the absence of acid; for it may happen, especially when the soil is near the neutral point, that positive tests for both acidity and carbonates are obtained. This condition is explained by the assumption that solid particles of calcium or magnesium carbonates form centers of alkalinity within a soil that is generally acid. Because of this fact any test made of a given soil ought to be repeated if it is to be thoroly reliable. It is also desirable to test samples from different depths. Following are the directions for making these tests:

The Litmus Paper Test for Acidity. Make a ball of fresh moist soil, break it in two, insert a piece of blue litmus paper, and press the soil firmly together again. After a few minutes examine the paper. If it has turned pink or red, soil acidity is indicated. The intensity of the color and the rapidity with which it develops indicates to some extent the amount of acidity. Needless to say the reliability of the test depends upon the quality of litmus paper used.

The Potassium Thiocyanate Test for Acidity. A more recently discovered test for soil acidity which promises to be more satisfactory than the litmus test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol (not denatured). When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. The conditions for a prompt reaction require a temperature that is comfortably warm.

The Hydrochloric Acid Test for Carbonates. Make a shallow cup of a ball of soil and pour into it a few drops of concentrated hydrochloric acid. If carbonates are present they are decomposed with the liberation of carbon dioxid, which appears as gas bubbles, producing foaming or effervescence. With much carbonate present the action is lively, but with mere traces of it the bubbles are given off slowly. If no carbonate, or very little, is indicated by the test, then it is advisable to apply limestone.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen costs from four to

five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for agricultural uses. *These are the chemical and the biological fixation of the atmospheric nitrogen.* Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of those legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for feed and seed as well as for nitrate production, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen, the possibilities of which now represent numerous compounds, will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes.

For easy figuring it may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy requires 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpeas contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of a soil varies according to its origin and the kind of farming practiced. Even virgin soils are found that are deficient in phosphorus.

On all lands deficient in phosphorus (except on those susceptible to serious erosion by surface washing or gullying) that element should be applied in considerably larger amounts than are required to meet the actual needs of the crops desired to be produced. The abundant information thus far secured shows positively that fine-ground natural rock phosphate can be used successfully and very profitably, and clearly indicates that this material will be the most economical form of phosphorus to use in all ordinary systems of permanent, profitable soil improvement. The first application may well be one ton per acre, and subsequently about one-half ton per acre every four or five years should be applied, at least until the phosphorus content of the plowed soil reaches 2,000 pounds per acre, which may require a total application of from 3 to 5 or 6 tons per acre of raw phosphate containing 12½ percent of the element of phosphorus.

Steamed bone meal and even acid phosphate may be used in emergencies, but it should always be kept in mind that a pound of phosphorus delivered in Illinois in the form of raw phosphate (direct from the mine in carload lots), is much cheaper than the same amount in steamed bone meal or in acid phosphate, both of which cost too much per ton to permit their common purchase by farmers in carload lots, which is not the case with raw phosphate. Landowners should bear in mind the fact that phosphorus additions to the soil in amounts above the immediate crop requirements represent a permanent investment, since this element is not readily lost in the drainage water as in the case of nitrogen. It is removed from the farm thru the sale of crops, milk, and animals.

Phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the fine-ground rock phosphate be intimately mixed with the organic material as it is plowed under.

The Potassium Problem

Normal soils, in which clay and silt form a considerable part of the constituency, are well stocked with potassium, altho it exists largely in insoluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be supplied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of normal soils are concerned, that the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have practically the same power as potassium to increase crop yield in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much

potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt, kainit, was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part perhaps because the potassium removed in the crops is mostly returned in the manure if properly cared for, and perhaps in larger part because the decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no plant food of value.

In considering the conservation of potassium on the farm it should be remembered that in average live-stock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in live-stock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by the actual crop requirements for plant food, magnesium and calcium are more limited in some Illinois soils than potassium. But with these elements we must also consider the loss by leaching.

Doctor Edward Bartow and associates, of the Illinois State Water Survey, have shown that as an average of 90 analyses of Illinois well-waters drawn chiefly from glacial sands, gravels, or till, 3 million pounds of water (about the average annual drainage per acre for Illinois) contained 11 pounds of potassium, 130 of magnesium, and 330 of calcium. These figures are very significant, and it may be stated that if the plowed soil is well supplied with the carbonates of magnesium and calcium, then a very considerable proportion of these amounts will be leached from that stratum. Thus the loss of calcium from the plowed soil of an acre at Rothamsted, England, where the soil contains plenty of limestone, has averaged more than 300 pounds a year as determined by analyzing the soil in 1865 and again in 1905. And practically the same amount of calcium was found by analyzing the Rothamsted drainage waters.

Common limestone, which is calcium carbonate ($CaCO_3$), contains, when pure, 40 percent of calcium, so that 800 pounds of limestone is equivalent to 320 pounds of calcium. Where 10 tons per acre of ground limestone was applied at Edgewood, Illinois, the average annual loss during the next ten

years amounted to 790 pounds per acre. The definite data from careful investigations seems to be ample to justify the conclusion that where limestone is needed at least 2 tons per acre should be applied every four or five years.

It is of interest to note that thirty crops of clover of 4 tons each would require 3,510 pounds of calcium, while the most common prairie land of southern Illinois contains only 3,420 pounds of total calcium in the plowed soil of an acre. Thus limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of surfur, such as exists in our common types of soil, and an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply to conditions in Illinois.

Physical Improvement of Soils

In the management of most soil types, one very important thing, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is

organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is being destroyed during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, corn stalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and corn stalks should be turned under, and not burned. Probably no form of organic matter acts more beneficially in producing good tilth than corn stalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of corn stalks is one and one-half times that of a ton of manure, and a ton of dry corn stalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the corn stalks during the winter and often rather late in the spring after the frost is out of the ground. This tramping by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The bad effect will be greater if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including a liberal use of legumes, in order to increase the organic matter of the soil either by plowing under the legume crops and

other crop residues (straw and corn stalks), or by using for feed and bedding practically all the crops raised and returning the manure to the land with the least possible loss. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations, applicable to the corn belt, which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover) or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years) ; or, in live-stock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be seeded four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Wheat (with clover)
Second year —Corn
Third year —Oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Wheat or oats (with colver)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotation

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover especially as a green manure for building up depleted soils, as well as a pasture and hay crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields Representing the More Important Types of Soil Occurring in Iroquois County)

In the earlier reports of this series it was the practice to incorporate in the body of the report the results of certain experiment fields, for the purpose of illustrating the possibilities of improving the soil of various types. The information carried by such data must, naturally, be considered more or less tentative. As the fields grow older new facts develop, which in some instances may call for the modification of former recommendations. It has therefore seemed desirable to separate this experiment field data from the more permanent information of the soil survey, and embody the same in the form of a supplement to the soil report proper, thus providing a convenient arrangement for possible future revisions as further data accumulate.

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the summarized results from certain of these fields which are representative of the types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

These fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots and each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, live-stock and grain farming. *In the live-stock system,* stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are supplied in the form of plant manures, including plant residues produced, such as stalks and straw, along with leguminous catch crops plowed under.

Rotations

Crops which are of interest in the respective localities are grown in definite rotations, and on most of the fields provision is made so that every crop in the rotation is represented every year. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. In the event of clover failure, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application are: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, the equivalent of 200 pounds of kainit. The initial application of limestone is usually 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

BROWN SILT LOAM

Several experiment fields have been conducted on brown silt loam soil at various locations in Illinois. Those located at the University have been in operation the longest and they serve well to illustrate the principles involved in the maintenance and improvement of this type of soil.

The Morrow Plots

It happens that the oldest soil experiment field in the United States is located on typical brown silt loam of the early Wisconsin glaciation, on the campus of the University of Illinois. This field was started in 1879 by George E. Morrow, who for many years was Professor of Agriculture, and these plots are known as the Morrow plots.

TABLE 1.—URBANA FIELD, MORROW PLOTS: BROWN SILT LOAM; PRAIRIE; EARLY WISCONSIN GLACIATION

Crop Yields in Soil Experiments—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
		Corn	Corn	Oats	Corn	Oats	Clover
1879–87	None	....	....	....	....	....	....
1888	None	54.3	49.5	....	....	48.6	....
1889	None	43.2	....	37.4	....	....	(4.04)
1890	None	48.7	54.3	....	....	....	(1.51)
1891	None	28.6	33.2	....	....	....	(1.46)
1892	None	33.1	....	37.2	70.2	....	....
1893	None	21.7	29.6	....	34.1	....	....
1894	None	34.8	....	57.2	....	65.1	....
1895	None	42.2	41.6	....	....	22.2	....
1896	None	62.3	....	34.5	....	....	....
1897	None	40.1	47.0	....	....	....	....
1898	None	18.1	....	....	....	....	....
1899	None	50.1	44.4	....	53.5	....	....
1900	None	48.0	....	41.5	....	....	....
1901	None	23.7	33.7	....	34.3	....	....
1902	None	60.2	....	56.3	....	54.6	....
1903	None	26.0	35.9	....	....	....	(1.11)
1904	None	21.5	....	17.5	55.3	....	....
1904	MLP	17.1	....	25.3	72.7	....	....
1905	None	24.8	50.0	....	....	42.3	....
1905	MLP	31.4	44.9	....	....	50.6	....
1906	None	27.1	....	34.7	....	....	(1.42)[1]
1906	MLP	35.8	....	52.4	....	....	(1.74)[1]
1907	None	29.0	47.8	....	80.5	....	....
1907	MLP	48.7	87.6	....	93.6	....	....
1908	None	13.4	....	32.9	....	40.0	....
1908	MLP	28.0	....	45.0	....	44.4	....
1909	None	26.6	33.0	....	....	....	(.65)[2]
1909	MLP	31.6	64.8	....	....	....	(1.73)[3]
1910	None	35.9	....	33.8	58.6	....	....
1910	MLP	54.6	....	59.4	83.3	....	....
1911	None	21.9	28.6	....	....	20.6	....
1911	MLP	31.5	46.3	....	....	38.0	....
1912	None	43.2	....	55.0	....	....	16.3[1]
1912	MLP	64.2	....	81.0	....	....	20.0[1]
1913	None	19.4	29.2	....	33.8	....	....
1913	MLP	32.0	25.0	....	47.8	....	....
1914	None	31.6	....	33.6	....	39.6	....
1914	MLP	39.4	....	58.2	....	60.4	....
1915	None	40.0	49.0	....	....	....	24.2[1]
1915	MLP	66.0	81.2	....	....	....	27.1[1]
1916	None	11.2	....	37.5	27.8	....	....
1916	MLP	10.8	....	64.7	40.6	....	....
1917	None	40.0	48.4	....	....	68.4	....
1917	MLP	78.0	81.4	....	....	86.9	....
1918	None	13.6	....	27.2	....	....	(2.58)
1918	MLP	32.6	....	59.3	....	....	(4.04)
1919	None	24.0	30.8	....	52.2	....	....
1919	MLP	43.4	66.2	....	70.8	....	....
1920	None	28.2	....	37.2	....	52.2	....
1920	MLP	54.4	....	51.6	....	69.7	....

[1]Soybeans.
[2]In addition to the hay, .64 bushel of seed was harvested.
[3]In addition to the hay, 1.17 bushels of seed were harvested.

TABLE 2.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY
Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover
		16 crops	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
1888 to 1903	None.......	39.7	41.0	44.0	48.0	47.6	(2.03)
		17 crops	*8 crops*	*9 crops*	*6 crops*	*6 crops*	*3 crops*
1904 to 1920	None.......	26.6	39.6	34.4	51.4	43.9	(1.55)[1]
	MLP.......	41.1	62.2	55.2	68.1	58.3	(2.50)[1]

[1]One crop of soybean hay.

The Morrow series now consists of three plots divided into halves and the halves are subdivided into quarters. On one plot corn is grown continuously; on the second corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904, receiving standard applications of farm manure with cover crops grown in the one-crop and two-crop systems. Phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. At the same time the rate of subsequent application of both forms of phosphorus was reduced to one-fourth the quantity, or to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per year. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre with the intention of standardizing the application to the rate of 1,000 pounds of limestone per acre per year.

FIG. 1.—CORN ON THE MORROW PLOTS IN 1910

Table 1 gives the yearly records of the crop yields, and Table 2 presents the same in summarized form.

Summarizing the data from these Morrow plots into two periods with the second period beginning in 1904 when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oats production, while the averages for the three-year system show an increase in corn yield and decreases in oats and clover. Unfortunately the numbers of crops included in these last averages are too small to warrant positive conclusions.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

The Davenport Plots

Another set of plots on the University campus at Urbana, forming a more extensive series than the Morrow plots, but of more recent origin, are the Davenport plots. Here each crop in the rotation is represented every year. These plots were laid out in 1895, but special soil treatment was not begun until 1901. They now comprize five series of ten plots each, and each series constitutes a "field" in a crop rotation system.

From 1901 to 1911 three of the series were in a three-year rotation system of corn, oats, and clover, while the remaining two series rotated in corn and oats. In 1911 these two systems were combined into a five-series field, with a crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field. The alfalfa occupies one series during a rotation of the other four crops, shifting to another series in the fifth year, thus completing the cycle of all series in twenty-five years.

The soil treatment applied to these plots has been as follows:

Legume cover crops were seeded in the corn at the last cultivation on Plots 2, 4, 6, and 8, from 1902 to 1907, but the growth was small and the effect, if any, was to decrease the returns from the regular crops. Crop residues (**R**) have been returned to these same plots since 1907. These consist of stalks and straw, and all legumes except alfalfa hay and the seed of clover and soybeans. Beginning in 1918 a modification of the practice was made in that one cutting of the red clover crop is harvested as hay. In conjunction with these residues a catch crop of sweet clover grown with the wheat is plowed under.

Manure (**M**) was applied preceding corn, at the rate of 2 tons per acre per year in 1905, 1906, and 1907; subsequently as many tons have been applied as there have been tons of air-dry produce harvested from the respective plots.

Lime (**L**) was applied on Plots 4 to 10 at the rate per acre of 250 pounds of air-slaked lime in 1902, and 600 pounds of limestone in 1903. No further application was made until 1911, when the system of cropping was changed. Since that time applications of limestone have been made at the rate of one-half ton per acre per year.

Phosphorus (**P**) was applied on Plots 6 to 9 at the rate of 25 pounds per acre per annum in 200 pounds of steamed bone meal; but beginning with 1908 rock phosphate at the rate of 600 pounds per acre per annum was substi-

TABLE 3.—URBANA FIELD, DAVENPORT PLOTS: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Ten-Year Average Annual Yields—Bushels or (tons) per acre
1911-1920

Serial plot No.	Soil treatment applied	Corn	Oats	Wheat	Clover 5 crops	Soybeans 5 crops	Alfalfa
1	0................	55.6	50.5	26.0	(2.42)	(1.47)	(2.43)
2	R................	57.1	52.3	28.7	1.47[1]	19.8	(2.46)
3	M................	66.3	61.9	28.2	(2.56)	(1.62)	(2.52)
4	RL...............	64.8	55.6	31.4	1.61[1]	20.3	(2.72)
5	ML...............	69.6	64.1	32.8	(2.90)	(1.67)	(3.03)
6	RLP..............	71.5	69.8	43.0	2.29[1]	23.5	(3.69)
7	MLP..............	73.0	68.6	40.0	(3.52)	(1.97)	(3.76)
8	RLPK.............	70.9	72.5	40.7	1.79[1]	25.5	(3.77)
9	MLPK.............	70.2	72.0	39.2	(3.40)	(2.20)	(3.73)
10	Mx5LPx5.........	65.9	71.4	40.6	(3.31)	(2.22)	(3.77)

[1]In addition to the clover seed, a crop of hay was harvested one year on Plots 2, 4, 6, and 8, yielding 2.38, 2.20, 2.54, and 2.39 tons, respectively.

tuted for the bone meal on one-half of each of these plots. These applications continued until 1918 when adjustments were begun, first to make the rate of application of rock phosphate four times that of the bone meal, and finally to reduce the amounts of these materials to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per annum. The usual practice has been to apply and plow under at one time all phosphorus and potassium required for the rotation.

Potassium (**K** = kalium) has been applied on Plots 8 and 9 in connection with the bone meal and rock phosphate, at the yearly rate of 42 pounds per acre, and mainly as potassium sulfate.

On Plot 10 about five times as much manure and phosphorus are applied as on the other plots, but this "extra heavy" treatment was not begun until 1906, only the usual lime, phosphorus, and potassium having been applied in previous years. The purpose in making these heavy applications is to try to determine the climatic possibilities in crop yields by removing the limitations of inadequate fertility.

It will be observed that the applications described above provide for the two rather distinct systems of farming already described. *The grain system,* in which animal manure is not produced and where the organic matter is provided by the direct return to the soil of all crop residues, is exemplified in Plots 2, 4, 6, and 8; and the *live-stock system,* in which farm manure is utilized for soil enrichment, is represented in Plots 3, 5, 7, and 9.

Table 3 shows a summary of the results obtained on the Davenport plots beginning with the year 1911, when the present cropping system was introduced.

When used in conjunction with phosphorus the crop residues and the manure appear about equally effective; but where phosphorus is not applied, the manure has been decidedly more effective, under the conditions of the experiment. It should be observed, however, in this connection, that the plowing under of clover is a very essential feature of the residues system, and that, as a matter of fact, there were five clover failures, when soybeans were substituted, during the ten years. Perhaps with a more reliable biennial legume than red clover, the results would have been more favorable for this system.

Manure
Yield: 1.43 tons per acre

Manure, limestone, phosphorus
Yield: 2.90 tons per acre

FIG. 2.—CLOVER ON THE DAVENPORT PLOTS IN 1913

By comparing Plots 2 and 3 with Plots 4 and 5, it is found that limestone has had a beneficial effect on all crops. What the financial profit amounts to depends obviously upon the market value of the crops and the cost of the limestone.

Comparing Plots 4 and 5 with Plots 6 and 7, respectively, there is found in all cases an increase in crop yield as a result of adding phosphorus. The effect on wheat is especially pronounced. Where limestone and phosphorus are applied in addition to the crop residues, an increase of 17 bushels of wheat, over the yield of the untreated land, has been obtained as a ten-year average.

The effect of adding potassium to the treatment is of much interest. Plots 8 and 9 are the same as Plots 6 and 7, respectively, except that potassium has been applied to the former. On the whole, no significant benefit is shown from the addition of potassium.

No benefit appears as the result of the extra-heavy applications of manure and phosphorus on Plot 10. In fact the corn yields are noticeably less here than on the plots receiving the normal applications of these materials.

The University South Farm

On the University South Farm, at Urbana, several series of plots devoted primarily to variety testing and other crop-production experiments are so laid out as to show the effects of certain soil treatments that have been applied.

Several different systems of crop rotation are employed and the crops are so handled as to exemplify the two general systems of farming, grain and livestock.

The summarized results presented in Table 4 represent three different systems of cropping. The first, designated as the Southwest rotation, is to be regarded as a good rotation for general practice, on this type of soil, under Illinois conditions. This is a four-field rotation of wheat, corn, oats, and clover. The second, or North-Central rotation, consisting of corn, corn, oats, and clover, represents a system very commonly practiced; and the third or South-Central rotation, consisting of corn, corn, corn, and soybeans, must be considered as a poor rotation from the standpoint of maintaining the productiveness of the land.

TABLE 4.—URBANA FIELD, SOUTH FARM: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Southwest Rotation: Series 100, 200, 400[1]: Wheat, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 9 crops	Oats[3] 9 crops	Wheat[3] 8 crops	Clover[4] 3 crops	Soybeans 7 crops
RP	62.3	51.9	41.0	1.05	17.3[5]
R	51.9	46.5	26.9	1.38	16.2[5]
M	59.7	50.2	29.1	(2.28)	(1.25)
MP	64.3	55.4	43.1	(2.86)	(1.51)
RLP	60.5	57.2	41.8	.64	16.4[5]
R	49.7	49.6	25.8	.83	14.7[5]
M	55.5	54.1	27.8	(1.71)	(1.28)
MLP	64.1	59.6	43.9	(1.77)	(1.58)

North-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Oats 9 crops	Clover 5 crops	Soybeans 4 crops
RP	56.7	51.1	56.1	.54	16.9
R	51.7	45.2	52.0	.50	16.0
M	54.9	46.7	52.1	(2.29)	(1.60)
MP	56.5	53.4	56.9	(2.73)	(1.74)

South-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Corn, Soybeans

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Corn 3d year 9 crops		Soybeans 9 crops
RP	51.9	44.0	41.3		20.0
R	45.5	39.9	35.2		19.2
M	50.1	42.1	33.5		(1.59)
MP	54.5	46.7	42.0		(1.66)

[1]Results from Series 300 and 800 are omitted on account of variation in soil type.
[2]Soybeans when clover fails.
[3]Only seven crops with limestone.
[4]Only one crop with limestone.
[5]Average of five crops.
[6]All phosphorus plots received ½ ton per acre of limestone in 1903.

TABLE 5.—COMPARING PRODUCTION OF CORN IN THREE DIFFERENT ROTATION SYSTEMS
ACRE YIELDS FROM PLOTS ON THE UNIVERSITY SOUTH FARM
Twelve-Year Average (1908-1919)—Bushels per acre

Rotation	Wheat-corn-oats-legume[1]	Corn-corn-oats-legume[2]		Corn-corn-corn-legume[3]		
Treatment	Corn	1st Corn	2d Corn	1st Corn	2d Corn	3d Corn
Organic manures	55.8	53.3	46.0	47.8	41.0	34.3
Organic manures, phosphorus	63.2	56.6	52.3	53.2	45.3	41.6

[1]Clover 3 crops, and soybeans 7 crops.
[2]Clover 5 crops, and soybeans 5 crops.
[3]Soybeans 9 crops.

On the whole, the "residues" have not returned yields quite so high as those produced by the manure treatment; but, as remarked above in the discussion of the Davenport plots, the residues system has probably been at a disadvantage thru frequent clover failures. On the North-Central rotation, where conditions seem to have been more favorable for clover, there is very little difference between the effect of manure and of residues.

Residues plowed under
Yield: 35.2 bushels per acre

Residues and rock phosphate
Yield: 50.1 bushels per acre

FIG. 3.—WHEAT ON THE UNIVERSITY SOUTH FARM IN 1911

In the rotation system in which limestone is being applied, no benefit of consequence to any of the crops except oats appears from the use of this material. The test, however, has hardly been of sufficient duration to warrant final conclusions; and furthermore, the comparison may be somewhat impaired by a possible residual effect of the small application of limestone made in 1903 to all the phosphorus plots.

The results obtained from the use of phosphorus are important because this element has been applied to these plots solely in the form of raw rock phosphate. The figures in almost every case show an increase in yield where the phosphorus has been applied, and in most cases this increase is very pronounced. The wheat is especially responsive to phosphorus.

The records furnish some interesting comparisons of corn yields produced under different systems of cropping. Table 5 gives a general summary of the corn yields only, in which the results from the residues and manure treatments are averaged together as "organic manures." The highest annual acre-yields are found where corn occurs but once in a rotation. Where corn is grown twice in succession, the annual acre-yields are less; and where corn occurs three times, there is a further reduction. Also, the first crop of corn within a rotation produces more than the second, and the second crop yields more than the third. These are useful facts for consideration in connection with problems of general farm management.

BLACK CLAY LOAM

The Hartsburg experiment field, representing black clay loam of the middle Illinoisan glaciation, is located in Logan county just east of Hartsburg. The work was begun here in 1913. There are five series of ten plots each. A crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field, is practiced. The soil treatments are as indicated in Table 6. The table also summarizes the

TABLE 6.—HARTSBURG FIELD: BLACK CLAY LOAM, PRAIRIE; MIDDLE ILLINOISAN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat 5 crops	Corn 8 crops	Oats 7 crops	Clover 4 crops	Soybeans 2 crops	Alfalfa 8 crops[1]
1	0	22.6	43.4	45.4	(1.98)	(1.29)	(3.30)
2	M	27.4	48.3	50.2	(2.41)	(1.64)	(3.61)
3	ML	34.2	56.9	57.9	(2.51)	(1.82)	(3.83)
4	MLP	38.2	56.0	57.3	(2.62)	(1.92)	(4.04)
5	0	33.3	46.8	43.8	.74[2]	25.8	(3.19)
6	R	34.0	58.2	55.6	1.22[2]	26.8	(3.60)
7	RL	32.0	63.7	54.9	1.32[2]	28.4	(3.28)
8	RLP	36.4	61.1	59.0	1.41[2]	26.1	(3.83)
9	RLPK	35.2	59.5	57.2	1.42[2]	26.4	(4.01)
10	0	31.7	46.7	46.9	(2.14)	(1.69)	(3.02)

[1]No residues except on last two crops.
[2]In addition to the clover seed, hay was harvested on Plots 5, 6, 7, 8, and 9 amounting to .56, 1.01, 1.11, 1.20, and 1.03 tons, respectively.

yields, by crops, for the period during which the plots have been under full treatment.

Under the conditions of these experiments, residues alone have proved to be more effective than manure alone in the production of wheat, corn, and oats.

Limestone used with manure has given such greatly increased yields as to leave no doubt about the profitableness of its use. When applied with residues, however, there appears to be on the whole little advantage from the use of limestone.

Phosphorus has given good returns on the wheat crop, but with the other crops its recommendation would be doubtful. In this connection attention should be called to the fact that chemical analysis of this black clay loam type generally shows a relatively high phosphorus content. The experience on this field seems to bear out what the analyses show.

The addition of potassium has produced a depressing effect on the yields of all grain crops, and with the alfalfa the small gain could scarcely be considered significant.

YELLOW-GRAY SILT LOAM

Yellow-gray silt loam exhibits an important variation with respect to limestone content. In some areas, altho limestone may be altogether absent in the surface stratum it is found in abundance at a short distance beneath the surface. Accordingly, variations in response to soil treatment are exhibited by different experiment fields located on this type. In view of this discrepancy it is thought well to introduce here the records of two fields, that are representative of the type but which show a marked diversity in results, one in northern Illinois and one in the southern part of the state.

The Antioch field is located on the late Wisconsin glaciation, in Lake county, close to the Wisconsin border. The field was started in 1902, with but a single series of ten plots, under a rotation of corn, corn, oats, and wheat; but beginning with 1911 the rotation has been wheat, corn, oats, and clover. It was started in order to learn as quickly as possible what effect would be produced by the addition to this type of soil of nitrogen, phosphorus, and potassium, used singly and in combination. These elements were all applied in commercial form until 1911, after which the use of commercial nitrogen was discontinued and crop residues were substituted in its place. Nitrogen was supplied in the earlier years in 800 pounds per acre of dried blood. Phosphorus is applied in 200 pounds of steamed bone meal, and potassium in 100 pounds of potassium sulfate. At the beginning, 470 pounds of slaked lime was applied; but since 1912 limestone has been applied at the rate of 1,000 pounds per acre per year.

Table 7 presents, in summarized form, the results from the Antioch field. Because of an abnormality in Plot 1, the results from this plot are not considered. The data show that phosphorus is the one element standing out prominently as producing consistently beneficial results. Potassium applied in addition to phosphorus has, on the whole, not produced profitable results. Also, the results are unfavorable for the application of limestone. Limestone, however, is abundant in the subsoil of this type in the region of this field.

Lime applied and residues plowed under

Lime and phosphorus applied

FIG. 4.—CLOVER IN 1913 ON ANTIOCH FIELD

TABLE 7.—ANTIOCH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LATE WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 8 crops	Oats 5 crops	Wheat 4 crops	Clover seed 2 crops
1	0	23.9	32.3	15.8	.50
2	L	21.3	26.8	13.2	.30
3	LR	21.3	29.9	20.6	.33
4	LP	30.7	43.6	36.7	1.08
5	LK	23.7	27.8	19.2	.57
6	LRP	33.8	43.3	33.3	.57
7	LRK	24.3	26.9	20.8	.59
8	LPK	25.1	38.2	30.9	1.26
9	LRPK	38.3	42.6	28.0	.33
10	RPK	38.4	44.7	30.2	.67

The Raleigh experiment field is located on the lower Illinoisan glaciation, in southern Illinois, in Saline county. This field is laid out into four series of ten plots each, under a rotation of wheat, corn, oats, and clover. The treatments, along with the summarized results, are given in Table 8.

The outstanding feature of these results is the effect of limestone. Altho manure alone produces a substantial increase, especially in the corn crop, when limestone is added a remarkable increase is found in all crops. A most important fact is that the organic matter can be effectively built up thru the use

Manure, limestone, phosphorus
Yield: 61 bushels per acre

Nothing applied
Yield: 15 bushels per acre

FIG. 5.—CORN ON RALEIGH FIELD IN 1920

TABLE 8.—RALEIGH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LOWER ILLINOISAN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 10 crops	Oats 10 crops	Wheat 6 crops	Clover 4 crops		Soybeans 4 crops
1	0	17.3	10.4	5.8	(.26)		(.65)
2	M	29.7	13.0	7.7	(.31)		(.81)
3	ML	40.9	20.0	21.0	(1.08)		(1.08)
4	MLP	41.2	20.3	21.5	(1.32)		(1.24)
5	0	17.3	10.3	7.0	(.00)	.01[2]	2.3
6	R	20.1	12.8	8.4	(.00)	.01[2]	3.0
7	RL	34.9	21.5	18.8	(1.60)[1]	.10[2]	5.8
8	RLP	36.5	22.7	21.2	(1.61)[1]	.09[2]	6.8
9	RLPK	41.9	23.6	22.4	(1.79)[1]	.12[2]	6.0
10	0	19.6	11.6	6.5	(1.06)		(.57)

[1]One crop only (1920).
[2]Average of two crops.

of crop residues, with the application of limestone, so that the crop yields are practically as high under this "grain system" of farming as where manure is used.

Phosphorus thus far has given only moderate returns in increased crop yields, but with an increasing quantity of organic matter and nitrogen it is probable that the phosphorus applications will show up more favorably on sub-

sequent crops. As to the use of potassium, it is to be noted that aside from an increase of 5.4 bushels of corn in the residues system, the beneficial effect has not been sufficient to justify the use of this material.

In accounting for the discrepancy in the response to limestone on these two fields, the fact is to be considered that the Antioch field is located on the late Wisconsin glaciation, where the subsoil contains large quantities of limestone; while the Raleigh field represents the lower Illinoisan glaciation, the soil of which is very acid to a great depth.

In view of these variations, a general recommendation for a complete treatment for soil of this type, that will apply to all localities, cannot be given out until more information is acquired.

Fortunately, however, each farmer can determine for himself the need of limestone for his land by applying the simple tests for the presence of carbonates and soil acidity, as explained under the discussion of limestone on page 36 of the Appendix.

Phosphorus, which has paid well on the Antioch field, and has given doubtful returns thus far at Raleigh, has varied considerably in its effect when used on other fields located on this same type of soil. In this situation, therefore, the present suggestion would be that each farmer might well try out phosphorus on his own land, on a limited scale, and be guided by the outcome of his experience. The low phosphorus content of the surface stratum of this soil is an indication that in a system of permanent agriculture the time is not far off when phosphorus will become a limiting element to crop production, and the wise farmer will watch carefully the indications and be ready to make timely provision for this need.

DUNE SAND

In 1913 the University came into possession of a tract of dune sand on terrace, in Henderson county, near the Mississippi river, upon which an experiment field was laid out to determine the needs of these sand soils. This field is divided into six series of plots. Corn, soybeans, wheat, sweet clover, and rye, with a catch crop of sweet clover seeded in the rye on the residues plots, are grown in rotation on five series, while the sixth series is devoted to alfalfa. When sweet clover seeded in the wheat fails, cowpeas are substituted.

No catch of alfalfa or of sweet clover was obtained till the alfalfa drill was used in seeding. This covers the seed about one-half inch deep.

Table 9 indicates the kinds of treatment applied, the amounts of the materials used being in accord with the standard practice, as explained on page 46.

The data make apparent the remarkably beneficial action of limestone on this sand soil. Where limestone has been used in conjunction with crop residues, the yield of corn has been doubled. The limestone has also produced a fair crop of rye and excellent crops of sweet clover and alfalfa.

This land appears to be quite indifferent to phosphorus treatment. The analysis shows, however, that the stock of phosphorus in this type of soil is not large, and it may develop as time goes on and the supply diminishes along with the production of good-sized crops, that the application of this element will become profitable.

Manure
Yield: Nothing

Manure and limestone
Yield: 4.43 tons per acre

FIG. 6.—ALFALFA ON OQUAWKA FIELD IN 1918

TABLE 9.—OQUAWKA FIELD: DUNE SAND, TERRACE

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 6 crops	Soy-beans[1] 5 crops	Wheat 6 crops	Sweet clover 4 crops	Rye 4 crops	Alfalfa 3 crops
1	0	14.3	(.89)	6.4	0	12.1	(.11)
2	M	18.9	(1.01)	8.1	0	13.3	(.13)
3	ML	23.4	(1.27)	9.7	(1.20)	20.1	(1.88)
4	MLP	22.2	(1.20)	10.1	(1.26)	19.5	(2.03)
					2 crops 2 crops		
5	0	14.4	3.5	7.4	(0) 0	13.7	(.14)
6	R	16.2	3.5	8.1	(0) 0	14.1	(.12)
7	RL	29.3	6.6	9.1	(1.47) 2.53	23.2	(2.05)
8	RLP	29.3	6.4	10.4	(1.39) 2.20	24.2	(1.90)
9	RLPK	32.7	6.0	9.4	(1.53) 2.84	23.7	(1.86)
10	0	11.4	(.60)	6.4	(0)	10.6	(.06)

[1] In 1918 sweet clover was killed by being cut for hay. Soybeans were seeded on these plots and the following yields obtained: .86, 1.10, 1.93, and 2.00 tons of hay per acre on Plots 1 to 4; 11.1, 9.9, 14.6, 15.8, and 16.6 bushels of seed per acre on Plots 5 to 9; and .62 ton of hay per acre on Plot 10.

Altho the results show an increase of 3.4 bushels of corn from the use of potassium salts, with ordinary prices this would not be a profitable treatment. The .64 bushel gain in sweet-clover seed is the average of two crops only, and this is insufficient data upon which to base conclusions. The other crops all show negative results from the potassium application.

Experience thus far shows rye to be better adapted to this land than wheat, and both alfalfa and sweet clover thrive better than soybeans. With these two legume crops thriving so well under this simple treatment, we have promise of tremendous possibilities for the profitable culture of this land, which hitherto has been considered as practically worthless.

Deep Peat

As representing the deep peat type of soil, the results are introduced from an experiment field conducted at Manito in Mason county during the years 1902 to 1905 inclusive.

The results of the four years' tests, as given in Table 10, are in complete harmony with the information furnished by the chemical composition of peat soil. Where potassium was applied, the yield was from three to four times as large as where nothing was applied. Where approximately equal money values of kainit and potassium chlorid were applied, slightly greater yields were obtained with the potassium chlorid, which, however, supplied about one-third more potassium than the kainit. On the other hand, either material furnished more potassium than was required by the crops produced.

The use of 700 pounds of sodium chlorid (common salt) produced no appreciable increase over the best untreated plots, indicating that where potassium is itself actually deficient, salts of other elements cannot take its place.

Applications of 2 tons per acre of ground limestone produced no increase in the corn crops, either when applied alone or in combination with kainit, either the first year or the second.

Reducing the application of kainit from 600 to 300 pounds for each two-year period reduced the yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainit (Plot 9) furnished 60 pounds of potassium for the four years, an amount sufficient for 84 bushels of corn (grain and stalks). Attention is called to the fact that this is practically the difference between the yield of Plot 9 (125.9 bushels) and the yield obtained from Plot 2 (42.9 bushels), the poorest untreated plot.

TABLE 10.—MANITO FIELD: DEEP PEAT

Corn Yields—Bushels

Plot No.	Soil treatment for 1902	Corn 1902	Corn 1903	Soil treatment for 1904	Corn 1904	Corn 1905	Four crops
1	None................	10.9	8.1	None................	17.0	12.0	48.0
2	None................	10.4	10.4	Limestone, 4000 lbs....	12.0	10.1	42.9
3	Kainit, 600 lbs........	30.4	32.4	Limestone, 4000 lbs.. Kainit, 1200 lbs.....	49.6	47.3	159.7
4	Kainit, 600 lbs....... Acidulat'd bone, 350 lb.	30.3	33.3	Kainit, 1200 lbs..... Steamed bone, 395 lbs.	53.5	47.6	164.7
5	Potassium chlorid, 200 lbs.............	31.2	33.9	Potassium chlorid, 400 lbs............	48.5	52.7	166.3
6	Sodium chlorid, 700 lbs.	11.1	13.1	None................	24.0	22.1	70.3
7	Sodium chlorid, 700 lbs.	13.3	14.5	Kainit, 1200 lbs.......	44.5	47.3	......
8	Kainit, 600 lbs........	36.8	37.7	Kainit, 600 lbs........	44.0	46.0	164.5
9	Kainit, 300 lbs........	26.4	25.1	Kainit, 300 lbs........	41.5	32.9	125.9
10	None................	14.9[1]	14.9	None................	26.0	13.6	69.4

[1]Estimated from 1903; no yield was taken in 1902 because of a misunderstanding.

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 23

DeKALB COUNTY SOILS

By J. G. MOSIER, H. W. STEWART, E. E. DE TURK, AND H. J. SNIDER

Prepared for publication by L. H. SMITH

URBANA, ILLINOIS, JUNE, 1922

IN RECOGNITION

The Soil Survey of Illinois was organized under the supervision of the late Dr. Cyril G. Hopkins. The work progressed for eighteen years under his guidance and the first eighteen soil reports bear his name as senior author. On October 6, 1919, Dr. Hopkins died in a foreign land in the service of the American Red Cross. It is the purpose to carry on to completion this great work of the Illinois Soil Survey in the spirit, and along the same general plan and lines of procedure, in which it was begun.

INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or land owner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and land owner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

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DeKALB COUNTY SOILS

APPENDIX

SUPPLEMENT

DE KALB COUNTY SOILS

By J. G. MOSIER, H. W. STEWART, E. E. DE TURK, and H. J. SNIDER
Prepared for Publication by L. H. SMITH[1]

LOCATION AND CLIMATE OF DE KALB COUNTY

DeKalb county is situated in the northern part of Illinois about twenty-five miles south of the Wisconsin line and fifty miles west of Lake Michigan. It is approximately 36 miles long and 18 miles wide, and has an area of 632.7 square miles. About five-sixths of the county lies in the early Wisconsin glaciation, and the remainder in the Iowan.

The temperature of DeKalb county is characterized by a wide range between the extremes of summer and winter. The greatest range of any year since 1884 at Sycamore in this county was 125 degrees. The lowest temperature recorded was —28°; the highest, 106°. The average date of the last killing frost in spring is May 2; the earliest in fall, October 5. The growing season therefore is about 156 days long.

The average annual precipitation at Sycamore from 1882 to 1920 was 33.65 inches. The average rainfall by months for this period was as follows: January, 1.69 inches; February, 1.68; March, 2.54; April, 3.06; May, 4.18; June, 3.94; July, 3.34; August, 3.22; September, 3.38; October, 2.77; November, 2.11; December, 1.74. The percentage of total rainfall for each season is: winter, 15.1; spring, 29.2; summer, 31.3; autumn, 24.4. The year of heaviest rainfall on record was 1883, when the precipitation was 50.91 inches; the driest year was 1901, when the rainfall was but 21.35 inches.

AGRICULTURAL PRODUCTION

DeKalb county is primarily agricultural. Practically the entire county is made up of tillable land, a large percentage of which is prairie. In 1920 there were 2,400 farms having an average of 157.7 acres, 147.4 acres of which was improved land. Fifty-one percent of these farms were operated by tenants. This was a decrease of almost 2 percent in the last ten years.

The principal crops are corn, oats, spring wheat, pasture, hay, barley, winter wheat, rye, clover, and soybeans. The Fourteenth Census of the United States (1920) reports the following as the acreage and yield of the principal crops. It must be remembered that these figures are for but a single year, that of 1919.

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[1] J. G. Mosier, in charge of soil survey mapping; H. W. Stewart, in charge of field party; E. E. DeTurk, in charge of soil analysis; H. J. Snider, in charge of experiment fields; L. H. Smith, in charge of publications.

Crops	*Acreage*	*Production*
Corn	109,839	5,085,706 bu.
Oats	64,922	2,529,138 bu.
Wheat	47,330	933,640 bu.
Barley	10,852	299,257 bu.
Rye	2,183	44,836 bu.
Timothy	8,213	12,670 tons
Timothy and clover mixed	28,073	50,691 tons
Clover	2,115	3,617 tons
Alfalfa	838	2,127 tons
Silage crops	14,023	119,490 tons
Corn cut for forage	8,794	23,882 tons

The acreage of pasture is not given by the census, but from other data it is found to be approximately 67,000.

The live-stock interests, including those of the dairy, are of considerable importance, as is shown by the following data, also taken from the census of 1920.

Animals and animal products	*Number*	*Value*
Horses	17,720	$1,743,381
Mules	363	44,675
Beef cattle	32,945	2,392,679
Dairy cattle	18,252	1,337,833
Sheep	14,012	174,389
Swine	71,177	1,828,779
Chickens and other poultry	302,353	326,038
Eggs and chickens	......	670,115
Dairy products	......	949,757

The total value of the live stock and their products is nearly eight and a half million dollars.

Fruit growing is not very important. There were about 80,000 quarts of small fruits, 12,800 bushels of apples, pears, and cherries, and 90,000 pounds of grapes produced in 1920.

SOIL FORMATION

The most important period in the geological history of the county from the standpoint of soil formation was that during which the material that later formed the soils was being deposited. This was the Glacial period. At that time snow and ice accumulated in the region of Labrador, west of Hudson Bay, and in the Rocky Mountains to such an amount that the mass pushed outward from these centers, especially southward, until a point was reached where the ice melted as rapidly as it advanced. As the ice advanced in these movements it buried everything, even the highest mountains, in its path. It would then recede slowly, and apparently normal conditions would be restored for a long period, after which another advance would occur. At least six of these great ice movements took place, each of which covered part of northern United States, altho the same parts were not covered every time.

The names of the glaciers that have had some part, either directly or indirectly, in the formation of the soils of Illinois are as follows: (1) the Nebraskan, which did not touch Illinois; (2) the Kansan, which covered the western parts of Hancock and Adams counties; (3) the Illinoisan, which covered all of the state except the northwest county (Jo Daviess), the southern part of Calhoun county, and the seven southernmost counties; (4) the Iowan, which covered a part of northern Illinois, the area covered being difficult to determine because of the effect of the subsequent glaciations; (5) the early Wisconsin,

which covered the northeast part of the state as far west as Peoria and as far south as Shelbyville; (6) the late Wisconsin, which extended to the west line of McHenry county and south to the town of Milford in Iroquois county.

In advancing from the distant northern centers of accumulation, the ice gathered up all sorts and sizes of material, including clay, silt, sand, gravel, boulders, and even large masses of rock. Some of these materials were carried several hundred miles, and the coarser masses rubbed against the surface rocks or against each other until largely ground into rock powder, which now constitutes much of the soil. When, thru the melting of the ice, the limit of advance was reached, the material carried by the glacier was dropped, accumulating in a broad, undulating ridge or moraine, called a lateral moraine if formed at the side of the glacier, and a terminal moraine if formed at the end. If the ice melted more rapidly than the glacier advanced, the terminus of the glacier would recede, and the material would be deposited somewhat irregularly over the land, back of the moraines. Such a formation is known as a ground moraine. A glacier often would advance again, but not so far as before; or it would remain stationary, and another moraine would be built up. These moraines or ridges have a steep outward slope and a very gradual inward slope.

A pressure of forty pounds per square inch is exerted by a mass of ice one hundred feet thick, and these ice sheets may have been hundreds or even thousands of feet in thickness. The materials carried along in the ice, especially the boulders and pebbles, became powerful agents for grinding and wearing away the surface over which the ice passed. Preglacial ridges and hills were rubbed down, valleys were filled with the debris, and the surface features were changed entirely. The mixture of materials deposited by the glacier is known as boulder clay, till, glacial drift, or simply drift.

THE GLACIATIONS OF DEKALB COUNTY

There were at least three ice advances that reached DeKalb county and covered it wholly or in part. The first was probably the Illinoisan glacier, which covered the entire county. This glacier melted and somewhat normal conditions were restored, as is indicated by the thick soil formed from the material deposited by it. This is known as the Sangamon soil.

The drift left by this glacier was buried by another ice sheet, the Iowan. Later the early Wisconsin glacier covered about five-sixths of the county. In this glaciation two morainal ridges were left which cross the county in a northeastern and southwestern direction. These ridges belong to the general Bloomington morainic system. The northern, or outer, ridge is broken thru at places by branches of the Kishwaukee river and is about one hundred feet higher than the general level of the district to the west. The southern, or inner, ridge is narrower and not so high as the outer ridge. The average depth of the drift in the county is about 150 feet. The greatest thickness of the drift, as determined in making wells, is 260 feet. Many large granite boulders are found on the moraines. Some of these are as much as eight feet in diameter.

The glaciers that covered DeKalb county left a deposit called till, glacial drift, or boulder clay (a mixture of boulders, gravel, sand, silt, and clay), but this deposit does not form the soil material except in small areas. The rock flour

produced by the grinding action of the glaciers was reworked by the wind and deposited over practically all of the county to a depth of three to six feet. This loessial, or wind-blown, material has been transformed into soil by weathering and by the accumulation of organic matter, and now covers all the county except those places where it has been removed by erosion. There is little doubt but that this wind-blown material was fairly uniformly deposited over the exposed surface, but it has subsequently been removed in places by erosion, so that the boulder clay is exposed on some of the more rolling areas. The deposit is thicker on the Iowan glaciation than on the early Wisconsin, partly because of a deeper original deposit (3 to 6 feet), and partly because there has not been so much erosion on this less rolling area.

During the melting of the glacier the streams draining this area were frequently flooded, and the water carried large amounts of rather coarse material, such as gravel and sand. This was deposited in the valleys, partly filling them. Later the streams cut down thru the fill, leaving gravel terraces. This gravel was later covered with the fine material that now constitutes the soil. In the northeast township this flood water spread out over a large area, with the result that an extensive gravel plain was formed that reaches over into Kane and McHenry counties. Subsequent deposits of fine material on the surface of the gravel have aided in forming an excellent soil.

PHYSIOGRAPHY AND DRAINAGE

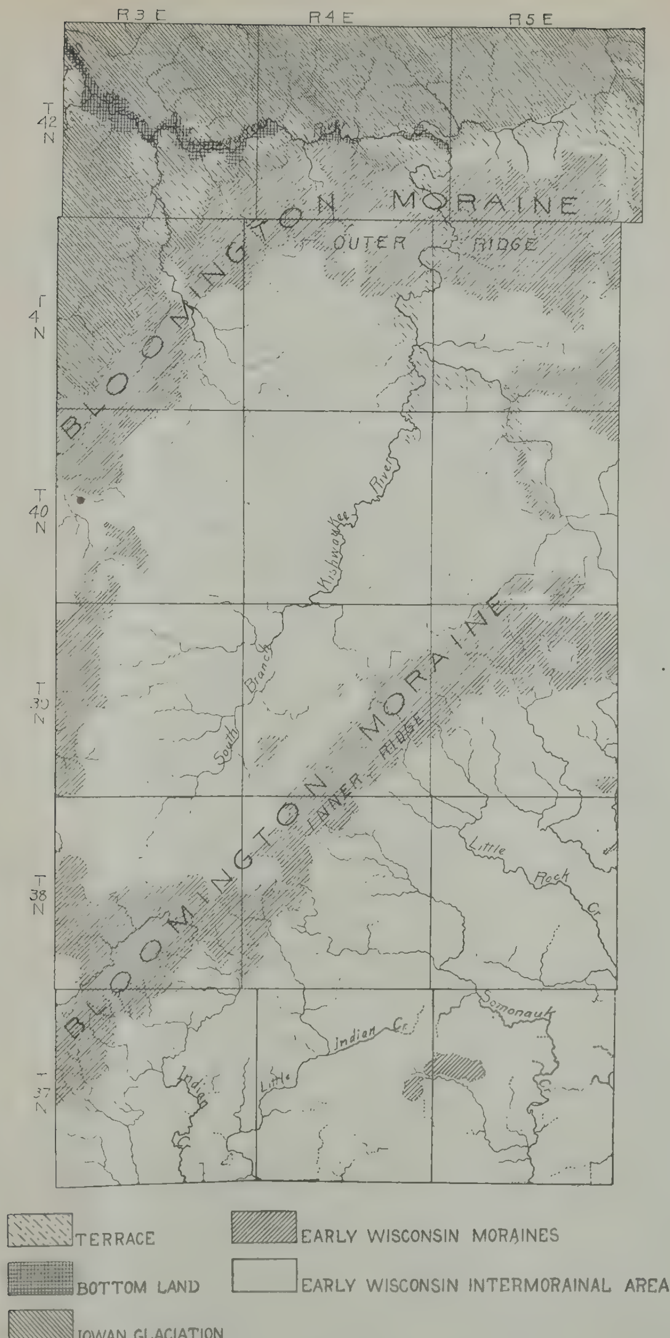
The county varies in topography from flat to slightly rolling. Even along the streams, hills do not exist to any extent. The principal variations are due to irregular deposition of glacial material. The moraines are characterized by an irregularly rounded, billowy topography, and they vary in width from three to six miles.

The southeast part of the county has a gradual slope to the Fox river, thru which this part is drained into the Illinois river. The northern two-thirds of the county is drained thru the Kishwaukee into the Rock river. Because of the flat character of the southeast part of the county, much tile draining has been done.

The altitudes of some places in DeKalb county are as follows: Carleton, 887 feet above sea level; Carleton Park, 855; Charter Grove, 875; Clair, 878; Cortland, 897; DeKalb, 886; Elva, 875; Esmond, 828; Fairdale, 787; Franks, 698; Genoa, 838; Hinckley, 740; Kingston, 795; Kirkland, 775; Lee, 939; Malta, 915; New Lebanon, 848; Rollo, 754; Sandwich, 667; Shabbona, 900; Shabbona Grove, 816; Somonauk, 690; Sycamore, 840; Van Buren, 740; Waterman, 820.

The highest altitude in the county, 955 feet, is found three miles north of Lee. Another high point occurs in the northwest part of Township 39 North, Range 5 East, which is about 940 feet.

In the terrace formation along the stream courses the soil is largely underlain by coarse material, such as sand and gravel, which provides favorable conditions for underdrainage.



MAP SHOWING THE DRAINAGE BASINS OF DEKALB COUNTY WITH MORAINAL, INTERMORAINAL, TERRACE, AND BOTTOM-LAND AREAS

SOIL TYPES

The soils of DeKalb county are divided into the following groups:

(a) Upland Prairie Soils, including the upland soils that have not been covered with forests and on which the luxuriant growth of prairie grasses has produced relatively large amounts of organic matter.

(b) Upland Timber Soils, including nearly all the upland areas that are now, or were formerly, covered with forests.

(c) Terrace Soils, including bench lands, or second bottom lands, formed by deposits from overloaded streams, and gravel outwash plains formed by broad sheets of water arising from the melting of the glaciers.

(d) Swamp and Bottom-Land Soils, including the overflow lands or flood plains along streams, the swamps, and the poorly drained lowlands.

Table 1 gives a list of the types of soil found in DeKalb county classified according to the groups described above. It also shows the area of each type in square miles and in acres, as well as the percentage of the total area. For example, it may be noted that the brown silt loam, or rolling prairie land, occupies more than four-fifths of the county. The accompanying map shows the location and boundary of each type of soil, even down to areas of a few acres.

For explanations concerning the classification of soils and the interpretation of the map and tables, the reader is referred to the first part of the Appendix.

TABLE 1.—SOIL TYPES OF DEKALB COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (700, 900, 1100)			
-26	Brown silt loam	516.82	330,765	81.68
-25	Black silt loam	7.96	5,094	1.26
-20	Black clay loam	.23	147	.04
-60	Brown sandy loam	.12	77	.02
-90	Gravelly loam	.12	77	.02
		525.25	336,160	83.02
	(b) Upland Timber Soils (700, 900, 1100)			
-34	Yellow-gray silt loam	41.46	26,534	6.55
-35	Yellow silt loam	.43	275	.07
-64	Yellow-gray sandy loam	.10	64	.01
		41.99	26,873	6.63
	(c) Terrace Soils (1500)			
1527	Brown silt loam over gravel	15.37	9,837	2.43
1525	Black silt loam	1.53	979	.24
1536	Yellow-gray silt loam over gravel	4.98	3,187	.79
1566	Brown sandy loam over gravel	.14	90	.02
		22.02	14,093	3.48
	(d) Swamp and Bottom-Land Soils (1400)			
1450	Black mixed loam	22.24	14,233	3.51
1401	Deep peat	2.02	1,293	.32
1402	Medium peat on clay	.04	26	.01
1454	Mixed loam	19.10	12,224	3.02
		43.40	27,776	6.86
	(e) Miscellaneous			
	Gravel pits	.04	26	.01
	Total	632.70	404,928	100.00

INVOICE OF PLANT FOOD IN DE KALB COUNTY SOILS

SOIL ANALYSIS

The composition reported in the accompanying tables is, for the more extensive types, the average of several analyses. These analyses show that soils, like most things in nature, are variable; but for general purposes the average may be considered sufficient to characterize the soil type.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed, but it should be understood that the rate of liberation, as explained in the Appendix (page 26), is governed by many factors.

For convenience in making practical application of the chemical analyses the results have been translated from the percentage basis and are presented here in terms of pounds per acre. In this, the assumption is made that for ordinary types a stratum of dry soil 6⅔ inches thick weighs 2,000,000 pounds. It is recognized that this value is only an approximation, but it is believed that it will suffice for the purposes intended. It is, of course, a simple matter to convert these figures back to the percentage basis in case one desires for any purpose to consider the information in that form.

THE SURFACE SOIL

In Table 2 are reported the amount of organic carbon (which serves as a measure of the organic matter), and the total quantities of nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium contained in 2 million pounds of the surface soil (the plowed soil of an acre about 6⅔ inches deep) of each type in DeKalb county.

Because of the extreme variations frequently found within a given soil type with respect to the presence of limestone and acidity, no attempt is made to include in the tabulated results figures purporting to represent the average amounts of these substances present in the respective types. Such averages cannot give the farmer the specific information he needs regarding the lime requirements of a given field. Fortunately, however, very simple tests which can be made at home will furnish this important information, and these tests are described on pages 28 and 29 of the Appendix.

The variation among the different types of soil of DeKalb county with respect to the content of important plant-food elements is very marked. For example, the deep peat contains, in the plowed soil of an acre, nearly twenty-two times as much nitrogen as does the yellow-gray sandy loam. Comparing the deep peat with the most common type in the county, we find about five times as much nitrogen in it as in the brown silt loam, while on the other hand the brown silt loam contains more than thirteen times as much potassium as is found in the deep peat. The supply of phosphorus in the surface soil varies from 760 pounds per acre in the yellow-gray sandy loam to 2,540 pounds in the black silt loam. A sulfur content of 240 pounds per acre is found in the yellow-gray sandy loam, while in the deep peat there are 7,110 pounds of this element. The magnesium varies in the different types from 2,560 to 39,780 pounds, and the calcium content ranges from 4,080 to 83,210 pounds per acre.

TABLE 2.—PLANT FOOD IN THE SOILS OF DEKALB COUNTY, ILLINOIS: SURFACE SOIL
Average pounds per acre in 2 million pounds of surface soil (about 0–6⅔ inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (700, 900, 1100)							
726, 926, 1126	Brown silt loam................	69 440	5 940	1 340	990	32 960	8 140	11 460
725, 925, 1125	Black silt loam.................	107 360	10 580	2 540	1 700	26 180	11 960	20 900
1120	Black clay loam................	102 540	9 500	2 440	1 400	35 600	15 200	22 100
760, 960, 1160	Brown sandy loam..............	34 540	3 000	1 080	660	28 340	4 780	6 840
790, 990, 1190	Gravelly loam..................	43 180	4 260	1 360	980	25 660	39 780	71 700
	(b) Upland Timber Soils (700, 900, 1100)							
734, 934, 1134	Yellow-gray silt loam...........	27 970	2 540	1 070	580	33 380	6 440	7 990
735, 935, 1135	Yellow silt loam................	26 800	2 540	880	640	44 480	6 720	7 460
764, 964	Yellow-gray sandy loam.........	20 300	1 500	760	240	23 180	2 560	4 520
	(c) Terrace Soils (1500)							
1527	Brown silt loam over gravel......	71 480	6 650	1 540	1 170	29 010	9 110	13 660
1525	Black silt loam..................	122 700	11 680	2 420	2 160	28 600	10 220	22 620
1536	Yellow-gray silt loam over gravel.	34 360	2 900	1 100	580	35 160	6 320	8 300
1566	Brown sandy loam over gravel...	25 460	2 140	960	540	24 680	3 240	4 080
	(d) Swamp and Bottom-Land Soils (1400)							
1450	Black mixed loam...............	149 150	14 000	2 510	2 040	22 090	19 570	83 210
1401	Deep peat[1]....................	380 320	32 810	1 900	7 110	2 380	5 520	44 480
1402	Medium peat on clay[1]..........	342 140	27 320	1 410	3 070	7 520	4 690	24 750
1454	Mixed loam.....................	55 380	4 460	1 660	900	30 200	6 420	10 420

LIMESTONE AND SOIL ACIDITY.—In connection with these tabulated data it should be explained that the figures on limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm, and even from field to field. Therefore no attempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, pages 28 and 29.

[1]Amounts reported are for 1 million pounds of deep peat and medium peat.

It is important to note that some of the plant-food elements are present in very limited quantities as compared with crop requirements. Some simple computations are of interest in this connection. Assume, for example, that a four-field crop rotation of wheat, corn, oats, and clover yields 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. These are high yields, but not impossible for they are sometimes obtained. It will be found that the most prevalent upland soil of DeKalb county, the brown silt loam, contains only enough total nitrogen in the plowed soil for the production of such yields to supply about twelve rotations.

TABLE 3.—PLANT FOOD IN THE SOILS OF DEKALB COUNTY, ILLINOIS: SUBSURFACE SOIL
Average pounds per acre in 4 million pounds of subsurface soil (about 6⅔–20 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (700, 900, 1100)							
726, 926, 1126	Brown silt loam	65 360	6 000	1 900	1 140	68 100	21 510	21 800
725, 925, 1125	Black silt loam	83 200	8 240	3 080	1 720	59 960	25 080	32 960
1120	Black clay loam	65 360	6 360	3 200	1 240	78 440	28 920	34 080
760, 960, 1160	Brown sandy loam	29 760	2 960	1 640	680	59 720	14 640	11 160
	(b) Upland Timber Soils (700, 900, 1100)							
734, 934, 1134	Yellow-gray silt loam	18 640	2 120	1 950	630	71 990	21 690	15 590
735, 935, 1135	Yellow silt loam	20 040	2 400	1 720	720	108 800	25 320	14 640
764, 964	Yellow-gray sandy loam	17 680	1 320	1 400	400	49 160	5 840	10 320
	(c) Terrace Soils (1500)							
1527	Brown silt loam over gravel	58 060	5 500	2 140	1 240	66 940	21 300	25 000
1525	Black silt loam	70 600	6 920	3 080	1 800	65 040	21 040	27 680
1536	Yellow-gray silt loam over gravel	28 400	2 920	2 120	760	71 800	19 520	17 880
1566	Brown sandy loam over gravel	16 480	1 480	1 360	600	53 040	9 680	9 520
	(d) Swamp and Bottom-Land Soils (1400)							
1450	Black mixed loam	113 840	10 580	3 580	1 860	53 220	51 220	106 660
1401	Deep peat[1]	825 040	65 320	3 880	19 880	8 360	12 300	72 980
1402	Medium peat on clay[1]	372 720	32 060	1 940	4 240	24 340	12 160	38 560
1454	Mixed loam	70 280	5 680	2 920	1 360	60 040	13 080	16 480

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1]Amounts reported are for 2 million pounds of deep peat and medium peat.

With respect to phosphorus, the condition differs only in degree, this soil containing no more of that essential element than would be required for about eighteen crop rotations yielding at the rates suggested above. On the other hand the amount of potassium in the surface layer of this common soil type is sufficient for more than 25 centuries if only the grain is sold, or for nearly 400 years if the total crops should be removed from the land and nothing returned.

These general statements relating to the total quantities of these plant-food materials in the plowed soil of the most prevalent type in the county certainly emphasize the fact that the supplies of some of these necessary elements of fertility are extremely limited when measured by the needs of large crop yields for even one or two generations of people.

THE SUBSURFACE AND SUBSOIL

In Tables 3 and 4 are recorded the amounts of plant food in the subsurface and the subsoil of the different types. It should be remembered, however, that these supplies are of little value unless the top soil is kept rich. These tables

also show great stores of potassium in the prevailing types of soil but only limited amounts of nitrogen and phosphorus, in agreement with the data for the corresponding surface samples.

TABLE 4.—PLANT FOOD IN THE SOILS OF DEKALB COUNTY, ILLINOIS: SUBSOIL
Average pounds per acre in 6 million pounds of subsoil (about 20–40 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (700, 900, 1100)							
726, 926, 1126	Brown silt loam	26 070	2 930	2 700	780	105 060	58 990	75 210
725, 925, 1125	Black silt loam	32 460	3 360	3 360	960	99 660	42 180	43 440
1120	Black clay loam	23 940	2 940	4 320	1 320	141 780	51 600	43 620
760, 960, 1160	Brown sandy loam	19 380	2 100	2 100	900	94 860	26 700	21 000
	(b) Upland Timber Soils (700, 900, 1100)							
734, 934, 1134	Yellow-gray silt loam	20 120	2 400	3 380	480	107 780	47 140	40 060
735, 935, 1135	Yellow silt loam	15 300	2 220	2 460	1 020	151 860	156 960	222 480
764, 964	Yellow-gray sandy loam	11 160	720	1 980	420	70 500	11 580	14 820
	(c) Terrace Soils (1500)							
1527	Brown silt loam over gravel	31 350	3 480	3 150	1 170	99 420	38 580	37 710
1525	Black silt loam	24 000	2 700	4 080	1 380	106 140	37 020	56 640
1536	Yellow-gray silt loam over gravel	21 660	2 520	3 900	720	96 000	39 900	33 600
1566	Brown sandy loam over gravel	16 020	1 380	1 680	660	81 480	13 560	17 100
	(d) Swamp and Bottom-Land Soils (1400)							
1450	Black mixed loam	88 980	7 620	5 700	1 890	84 360	102 810	187 710
1401	Deep peat[1]	801 900	57 420	5 220	24 690	27 600	22 620	83 610
1402	Medium peat on clay	285 060	20 520	3 120	6 660	112 200	49 500	64 440
1454	Mixed loam	41 400	3 660	3 900	1 320	96 780	26 160	28 200

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1]Amounts reported are for 3 million pounds of deep peat.

DESCRIPTION OF INDIVIDUAL SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of DeKalb county cover 525.25 square miles, or more than four-fifths of the area of the county. They usually occupy the less rolling and comparatively level land, altho some exceptions to this are to be found. These prairie soils are dark in color owing to their relatively high organic-matter content. This land was originally covered with prairie grasses, the partially decayed roots of which have been the principal source of the organic matter. The flat, poorly drained areas contain the greatest amounts of organic matter, owing to the more luxuriant growth of grasses in such situations and to the excessive soil moisture which has provided conditions more favorable for their preservation.

Brown Silt Loam (726, 926, 1126)

Brown silt loam is the most extensive type in DeKalb county, covering 516.82 square miles, or more than 80 percent of the area of the county. It is found on the more level land, a considerable portion of which needs artificial drainage. While the type is primarily prairie, yet in some sections timber has extended over it to a slight extent. The trees found on the timbered areas are usually bur oak, wild cherry, and elm, but their occupation of the soil has not been sufficiently long to change its character to any great extent. The type, however, may include some small areas of yellow-gray silt loam (—34) too small to be shown on the map.

The surface soil, 0 to 6⅔ inches, is a brown silt loam varying from a yellowish brown on the more rolling areas to a dark brown or black on the more nearly level and poorly drained tracts. In physical composition it varies to some extent, but it normally contains from 50 to 75 percent of the different grades of silt. In the low areas the proportion of clay is usually higher than on the more rolling parts, where a perceptible amount of sand may occur. On account of of the varied topography of the type, the organic-matter content in the surface soil is rather variable, but it averages about 6 percent, or 60 tons per acre. In the more rolling phase, small patches are found which have been eroded to such an extent that the yellow subsoil appears. These areas are usually not large enough to be shown on the map as a separate type.

The natural subsurface is represented by a stratum varying from 5 to 16 inches in thickness. This variation is due to erosion, the stratum being thinner on the more rolling areas. In physical composition the subsurface varies about the same as the surface soil, but on the less rolling areas it normally contains a larger percentage of clay, while on the more rolling areas the sand content becomes greater. The organic-matter content varies with topography in the same manner as the surface, being greater on the more level land. It averages about 2.7 percent, or 54 tons per acre in a stratum 13⅓ inches thick. In color the subsurface varies from a dark brown or almost black to a light yellowish brown, which becomes lighter with increasing depth.

The natural subsoil begins 11 to 22 inches beneath the surface and extends to an indefinite depth. It varies from a yellow to a drabbish yellow, clayey

material, sometimes composed wholly or in part of boulder clay or drift. The stratum sampled (20 to 40 inches) contains about .7 percent of organic matter. In some of the flat areas that are not subject to erosion, but where material has washed in from the higher surrounding land, the subsoil to a depth of 40 inches does not reach the boulder clay.

Each of the three strata is pervious to water, so that drainage takes place with little difficulty.

Management.—When the virgin brown silt loam was first cropped, the soil was in fine tilth, worked easily, and much less effort was required to produce a good seed bed than is now the case where the soil has been heavily cropped for many years and where the organic matter has not been maintained. Unless the moisture content is very favorable, the soil under this latter condition plows up cloddy, and the clods may remain all season. Much plant food will be locked up in them, and the best results cannot be obtained. The remedy for poor tilth is to increase the amount of organic matter by turning under every available form of vegetable matter, such as farm manure, corn stalks, straw, clover, stubble, and even weeds. The addition of fresh organic matter is not only of great value in improving the physical condition of this type of soil, but it is equally important because of its nitrogen content, and also because of its power, as it decays, to liberate potassium from the inexhaustible supply in the minerals of the soil and phosphorus from the phosphate contained in or applied to the soil. The deficiency of organic matter in the soil is shown by the way fall-plowed land runs together during the winter. In the spring, fall-plowed land should be disked early and deep for the purpose of conserving moisture, raising the temperature, and making plant food available.

For permanent, profitable systems of farming on brown silt loam, phosphorus should usually be applied liberally, and sufficient organic matter should be provided to furnish the necessary amount of nitrogen. While the subsoil usually contains an abundance of carbonates, on the prevailing phase of the type limestone is becoming deficient in the upper strata so that an application of 1 to 2 tons of limestone per acre is advisable, and in the preparation of the land for alfalfa heavier applications are justifiable. To enrich the soil in phosphorus, ½ to 1 ton of finely ground rock phosphate per acre should be applied about every four years. This treatment, along with the judicious return to the land of organic manures made from a good rotation, will not only maintain but will increase the fertility of this soil.

If grain farming is practiced, a good rotation to be suggested might be wheat, corn, oats, and clover, with an extra seeding of clover (preferably sweet clover) as a cover crop in the wheat, to be plowed under late in the fall or in the following spring for corn. Most of the crop residues, including the clover chaff from the seed crops, should also be plowed under. In live-stock farming, this rotation may be extended to five or six years by seeding both timothy and clover with the oats, and pasturing one or two years. In either the grain or the live-stock system, alfalfa may be grown on a fifth field and moved every rotation, the hay being fed or sold. Other suggestions for various crop rotation programs will be found in the Appendix (page 34).

For an account of field experiments on this type of soil the reader is referred to page 37 of the Supplement.

Black Silt Loam (725, 925, 1125)

Black silt loam is confined to small areas in depressions and along streams. It is generally scattered over the county and occurs in areas similar in location to those occupied by black clay loam in central Illinois. The type covers 5,094 acres, or 1.26 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a black, granular, silt to clayey silt loam. It contains normally about 9.2 percent of organic matter, or 92 tons per acre, altho in certain small areas the organic-matter content may vary from that of brown silt loam to that of muck.

The natural subsurface is represented by a stratum about 12 inches thick, and is a black silt loam passing into a drab clayey silt at 18 to 20 inches in depth. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 3.6 percent, or 72 tons per acre.

The subsoil is a drab or yellowish drab clayey silt or silty clay, sometimes containing pebbles. All strata are readily pervious to water.

Management.—The first consideration in the management of this type is drainage. The content of nitrogen and phosphorus is high, and no attention need be given these elements for some time if a good rotation is practiced. The limestone is often low, and applications may soon be necessary to produce the best results with legumes.

Alkali spots are common in this type. Applications of 150 to 200 pounds of potash salts per acre, or of several tons of coarse stable manure, or sweet clover turned under, will usually be effective in counteracting the effect of the alkali. These spots should be thoroughly tiled, as the leaching out of the alkali is about the only permanent remedy for removing it.

Black Clay Loam (1120)

The areas of black clay loam are about twelve in number and the largest does not cover more than 40 acres. The total area covered by this type is about 147 acres. A small area occurring on the terrace is included with this upland type.

The surface soil, 0 to 6⅔ inches, is a black, plastic, granular clay loam containing about 8.8 percent of organic matter, or 88 tons per acre.

The subsurface is a black clay loam with about 2.8 percent of organic matter, or 56 tons per acre.

The subsoil is a drab to yellowish drab silty clay or clayey silt.

Management.—Drainage is the first requirement of this type. It is abundantly supplied with plant food, but is somewhat acid and may need limestone for legumes, altho there are areas where alkali is so abundant as to be injurious. The treatment for alkali is the same as that described for the alkali spots in the preceding type.

Brown Sandy Loam (760, 960, 1160)

Brown sandy loam occurs in a few small isolated areas covering in total about 77 acres. It has been formed by sand blown from the bottom land onto the adjoining upland.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam containing about 3 percent of organic matter, or 30 tons per acre.

The natural subsurface, consisting of a stratum about 9 inches thick, is a brown sandy loam. The stratum as sampled (6⅔ to 20 inches), contains about 1.3 percent of organic matter.

The subsoil is a sandy silt or a silty sand of a yellow color.

Management.—The type is fairly well supplied with phosphorus and at present the most important consideration is the maintenance of the organic-matter and nitrogen contents. The recommendation, therefore, is the same as that suggested for brown silt loam.

Gravelly Loam (790, 990, 1190)

Gravelly loam occurs in several small spots in various parts of the county and covers as a total about 77 acres. An eskerlike gravel ridge about one mile in length, in Sections 5 and 6, Township 38 North, Range 5 East, is the largest area. The type is variable and of little agricultural value.

(b) UPLAND TIMBER SOILS

The upland timber soils usually occur along streams, altho two exceptions are found in DeKalb county where forests exist remote from streams. Timber soils are characterized by a yellow, yellowish gray, or gray color, due to their low organic-matter content resulting from the long-continued growth of forest trees. As the forests invaded the prairies, two effects were produced: (1) the shade from the trees prevented the growth of prairie grasses, the roots of which are mainly responsible for the large amount of organic matter in prairie soils; (2) the trees themselves added very little organic matter to the soil, for the leaves and fallen branches either decayed completely or were burned by forest fires. As a result the timber soils contain a relatively low percentage of organic matter.

The total area of upland timber soils in DeKalb county is 41.99 square miles.

Yellow-Gray Silt Loam (734, 934, 1134)

Yellow-gray silt loam occurs in the outer timber belts along streams, and in the less rolling of the timbered morainal areas. The type covers 41.46 square miles, or 6.55 percent of the entire area of DeKalb county. In topography, it is sufficiently rolling for good surface drainage, without much tendency to wash if proper care is taken. The effect of the prevailing southwesterly winds may be seen in the distribution of the type. It is nearly all on the north and east side of the Kishwaukee river. The wind, as well as prairie fires, controlled such distribution.

The surface soil, 0 to 6⅔ inches, is a yellow, yellowish gray, gray, or brownish gray silt loam, having a floury feel. The more nearly level areas incline toward a grayish color, while the more rolling phase of the type has a yellow or brownish yellow color. As the type approaches the brown silt loam (—26), the organic matter increases until it grades into that type. The organic-matter content averages 2.4 percent, or 24 tons per acre, and is somewhat lower in the Iowan glaciation than in the early Wisconsin.

The natural subsurface soil is represented by a stratum from 3 to 10 inches thick. It is usually a gray, grayish yellow, or yellow silt loam, somewhat pulverulent, but becoming more coherent and plastic with increasing depth. The subsurface as sampled (6⅔ to 20 inches) contains about .8 percent of organic matter, or 16 tons per acre in four million pounds of soil.

The subsoil is a yellow or mottled grayish yellow, clayey silt or silty clay, somewhat plastic when wet, but friable when only moist, and pervious to water.

Owing to the removal by erosion of part of the loessial material, glacial drift is sometimes encountered at a depth of less than 40 inches. The glacial drift may be locally a very gravelly deposit, but usually it is a slightly gravelly clay.

Management.—In the management of this yellow-gray silt loam, one of the most essential points is the maintaining or the increasing of organic matter. This is necessary in order to supply nitrogen, to liberate mineral plant food, to give better tilth, to prevent "running together," and, on some of the more rolling phases, to prevent washing.

Another essential is that the acidity of the soil be neutralized by the application of ground limestone, so that clover, alfalfa, and other legumes may be grown more successfully. The initial application may well be 2 to 4 tons per acre, after which a sufficient amount may be applied to keep the soil in good condition for growing legumes. Since the soil is poor in phosphorus, this element should be supplied, preferably in connection with farm manure or clover plowed under. In permanent systems of farming, finely ground natural rock phosphate will be found the most economical form in which to supply the phosphorus.

Among the crops deserving of special consideration for this type of soil are sweet clover and alfalfa. On soil deficient in organic matter sweet clover grows better than almost any other legume, and the fact that it is a very deep-rooting plant makes it of value for opening up the subsoil, increasing the organic matter, and preventing washing. Slopes that have been made worthless by washing may be made profitable as pasture by growing sweet clover. The blue grass of pastures may well be supplemented by sweet clover and alfalfa, and a larger growth obtained, because the legumes provide the necessary nitrogen for the blue grass.

To get alfalfa well started requires the liberal use of limestone, thoro inoculation with nitrogen-fixing bacteria, and a moderate application of farm manure. If manure is not available, it is well to apply about 500 pounds per acre of acid phosphate or steamed bone meal, mix it with the soil, by disking if possible, and then plow it under. The limestone (about 4 or 5 tons per acre) should be applied after plowing and should be mixed with the surface soil in the preparation of the seed bed. The special purpose of this treatment is to insure for the alfalfa a vigorous early growth.

See page 50 of the Supplement for an account of field experiments on this type of soil.

Yellow Silt Loam (735, 935, 1135)

Yellow silt loam covers only 275 acres in DeKalb county. It occurs as hilly and badly eroded land on the inner timber belts adjacent to the stream valleys, usually only in narrow, irregular strips. In topography it is very

rolling, and in most places so badly broken that it should not be cultivated because of the danger of injury from washing.

The surface soil, 0 to 6⅔ inches, is a yellow or grayish yellow, pulverulent silt loam. It varies greatly in color and texture, owing to recent washing. In places the natural subsoil may be exposed. This exposure gives the surface a decidedly yellow color. When freshly plowed the soil appears yellow or brownish yellow, but when it becomes dry after a rain, it is of a grayish color. In some places the surface soil is formed from glacial drift, but this is only on very limited areas and on the steepest slopes. The organic-matter content averages 2.3 percent, or 23 tons per acre.

The natural subsurface varies from a yellow silt loam to a yellow clayey silt loam, and on the slopes that have been subjected to recent erosion, may consist of glacial drift. The stratum as sampled (6⅔ to 20 inches) contains about .8 percent of organic matter, or 16 tons per acre.

The natural subsoil is composed almost entirely of yellow boulder clay. Where recent erosion has taken place, all strata may be boulder clay.

Management.—One of the best uses to which this type can be put is permanent pasture. As a rule it cannot be satisfactorily cropped in ordinary rotations because it is so hilly, but it may be used very successfully for long rotations with pasture or meadow much of the time. Where both the surface and subsurface are acid, ground limestone may well be used for legumes in the rotation or even as a top dressing to encourage their growth in pastures. Where this type has been long cultivated and thus exposed to surface washing, it is particularly deficient in nitrogen. Among the crops that are perhaps best adapted to this type sweet clover and alfalfa should be mentioned. Suggestions concerning their culture have already been given in connection with the discussion of yellow-gray silt loam (page 15).

Yellow-Gray Sandy Loam (764, 964, 1164)

Yellow-gray sandy loam occurs principally in the northern part of the county as a few small areas, which make a total of 64 acres.

The surface soil, 0 to 6⅔ inches, is a yellow or grayish yellow sandy loam usually containing some gravel; in a few instances small patches of gravelly loam occur. The soil is made largely from sandy till. The organic-matter content is about 1.8 percent, or 18 tons per acre.

The natural subsurface stratum varies from 3 to 10 inches in thickness. It is of a lighter color than the surface soil owing to the smaller amount of organic matter present. This stratum is usually formed from gravelly, sandy till, but it often contains a considerable proportion of clay.

The subsoil varies from gravelly till to sand.

Management.—For the improvement of this type, the addition of organic matter and nitrogen is essential. Limestone should also be applied liberally for the best results with legumes. Where the subsurface and subsoil are very compact, owing to the presence of silt and clay, sweet clover should be grown to loosen the subsoil.

(c) TERRACE SOILS

The terrace soils in DeKalb county usually occur along streams. They were formed at a time when the streams, owing to melting glacier ice, were much larger than they are at present, and carried large amounts of coarse material such as sand and gravel. Upon any decrease in their velocity, these overloaded streams would deposit debris along their courses; and this resulted in the partial filling of the valley and the forming of what are now the terraces, bench lands, or second bottom lands. Finer material later deposited over this sand and gravel forms the present soil.

When the streams again reached their normal size after the glacier had melted, they began cutting down thru the deposit, and they are now so low that the terraces, or benches, do not overflow. A gravel outwash plain occurs in the northeastern part of Township 42 North, Range 5 East, that was formed when the shallow water of the melting ice spread over a large level area and deposited sand and gravel which was later covered with a fine material well adapted to forming a good soil.

Brown Silt Loam over Gravel (1527)

Brown silt loam over gravel is found principally in the northern half of the county along the South Branch of the Kishwaukee river, occurring almost entirely on the south and west sides of this stream. Another area is found in the northeast part of the county along the county line. This is a gravel outwash plain. Doubtless at one time some of the water of Coon creek valley flowed west across Sections 15 and 22, Township 42 North, Range 5 East, into the South Branch of the Kishwaukee. The type covers an area of 9,837 acres, or nearly 2.5 percent of the county. The depth to gravel varies from 30 to more than 50 inches, the average being a little more than 40 inches.

The surface soil, 0 to 6⅔ inches, is a brown silt loam varying to black. In physical composition it varies from a clayey silt loam to a loam or even to a sandy loam in areas too small to be shown on the map. It usually contains a perceptible amount of sand. The topography is generally flat, but slight undulations may occur that were probably produced by the channels of the flooded streams. The surface stratum contains approximately 6.2 percent of organic matter, or 62 tons per acre, the amount varying from 47 to 77 tons per acre.

The natural subsurface varies from 7 to 16 inches in thickness. The stratum sampled (6⅔ to 20 inches) contains about 2.5 percent of organic matter, or 50 tons per acre. In physical composition it is about the same as the surface soil.

The subsoil is a yellow to drabbish mottled yellow silt loam, with some gravel appearing in the deeper subsoil.

All strata are pervious to water, so that drainage is practically perfect where the water table is sufficiently low. The gravel is so far from the surface that crops do well even in years of some drouth. This is one of the best of the terrace types.

Management.—In the improvement of this type limestone, phosphorus, and organic matter should be provided in about the same amounts as those recommended for the brown silt loam of the prairie (—26). However, because of the

greater porosity of this type, applications of phosphorus are likely to occupy third place in immediate effect.

Black Silt Loam (1525)

Black silt loam occurs only in the northern part of the county in Township 42 North along the Kishwaukee, and covers 979 acres. The topography is flat.

The surface soil, 0 to 6⅔ inches, is a black granular silt loam, locally becoming a clayey silt loam. This stratum contains about 10.6 percent of organic matter, or 106 tons per acre.

The natural subsurface soil is from 10 to 14 inches in thickness. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 3 percent.

The subsoil is a pale yellow to a drabbish yellow silt or clayey silt. It contains about .7 percent of organic matter.

Management.—The strata are pervious to water and drainage takes place readily by means of tile. Aside from drainage, good cultivation is about the only requirement at present, since the plant-food elements are usually abundant. Some alkali areas occur which may be greatly improved by turning under sweet clover.

Yellow-Gray Silt Loam over Gravel (1536)

With the exception of two small areas near Sandwich, yellow-gray silt loam over gravel is found in the northern half of the county, chiefly along the east and north sides of the Kishwaukee river. The type covers altogether 3,187 acres.

The surface soil, 0 to 6⅔ inches, is a grayish or yellowish gray silt loam, containing about 3 percent of organic matter, or 30 tons per acre. It varies in physical composition from a silt loam to a loam, and in small areas it may approach even a sandy loam.

The natural subsurface, comprizing a stratum from 6 to 10 inches thick, is a yellow to grayish yellow silt loam. The stratum sampled (6⅔ to 20 inches) contains about 1.3 percent of organic matter.

The subsoil is a clayey silt of a yellow or slightly grayish yellow color. Gravel occurs at a depth of 38 to 48 inches.

Management.—The low content of organic matter and nitrogen calls for the liberal use of leguminous crops, but to make conditions most favorable for their growth limestone should be applied at the rate of about 2 tons per acre. Phosphorus is likewise low and this element should be replenished by the use of rock phosphate.

Brown Sandy Loam over Gravel (1566)

Brown sandy loam over gravel occurs in a few small areas in the northeastern part of the county, and covers a total of 90 acres. The gravel lies from 40 to 50 inches below the surface.

The surface soil, 0 to 6⅔ inches, is a rather light colored brown sandy loam containing about 2.2 percent of organic matter, or 22 tons per acre.

The natural subsurface soil is represented by a stratum 4 to 9 inches thick. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about .7 percent.

The subsoil is a yellow sand to silty sand. Gravel occurs at 40 to 50 inches.

Management.—This type should be managed the same as the brown sandy loam of the upland (see page 14).

(d) SWAMP AND BOTTOM-LAND SOILS

In the group designated as swamp and bottom-land soils are included the overflow land or flood plains along streams, the swamps, and the poorly drained lowlands. The four types recognized as belonging to this group make up nearly 7 percent of the area of DeKalb county.

Black Mixed Loam (1450)

Black mixed loam occurs in a large number of small, isolated areas all over the county. These occur principally in low places that were formerly swamps, ponds, or sloughs. The largest areas of this type are found in the northeast part of the county. The total area of this soil is 22.24 square miles, or 14,233 acres.

The surface soil, 0 to 6⅔ inches, varies widely in its physical composition. For example, on a single ten acres, borings of shallow peat, black sandy loam, peaty loam, and gravelly loam were found. The samples taken to represent the type contained approximately 12.9 percent of organic matter.

The natural subsurface varies in thickness from 8 to 24 inches. In physical composition, it varies in somewhat the same manner as the surface, except that it is generally lighter in color. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 9.8 percent.

The subsoil is more uniform than the other strata and is usually a gray, drab, or yellow silty or clayey material.

Management.—Drainage is the first requirement and since all strata are pervious, drainage is a comparatively easy matter if a sufficient outlet can be obtained. All varieties of the type are very rich in nitrogen and elements of plant food generally, with possibly the exception of potassium in the more peaty phase of the type.

Deep Peat (1401)

Deep peat is well distributed over the county, but usually occurs only in small areas. The total area of the type is 1,293 acres.

The surface soil, 0 to 6⅔ inches, is a brown to black peat, containing about 65.6 percent of organic matter, or 328 tons per acre.

The subsurface stratum is about 13 inches thick and is similar to the surface except that it contains more organic matter, about 71.1 percent.

The subsoil contains, in the area sampled, about 46 percent of organic matter.

Management.—Drainage is of first importance with this type, but in many cases is very difficult to secure. Tile cannot be laid to the best advantage in peat on account of irregular settling and the consequent displacement of the line. This difficulty may be partly overcome by placing the tiles upon boards laid in the bottom of the ditch.

Where thoro drainage can be provided, either by the above method, by open ditches, or by laying tiles deep enough to secure a solid bed for them, very marked improvement can be made in the productive power of deep peat by the liberal use of potassium, which is by far the most deficient element. The type is well supplied with phosphorus.

For an account of field experiments on deep peat the reader is referred to page 53 of the Supplement.

Medium Peat on Clay (1402)

Medium peat on clay is found in only a few small areas in the northern half of the county and covers an area of but 26 acres.

The surface soil, 0 to 6⅔ inches, is a brown to black peat with about 59 percent of organic matter.

The subsurface contains about 32 percent of organic matter.

The clay subsoil contains about 8.2 percent of organic matter.

Management.—If this type is not productive when well drained, it may, in some cases where the clay is not too deep, be improved by extra deep plowing. By this process clayey material, with its higher potassium content, is incorporated with the peat. When this cannot be done, the use of coarse manure or of commercial potassium is advised.

Mixed Loam (1454)

Mixed loam occurs as irregular bottoms along the streams, practically all of which overflow. The total area covered is 12,224 acres, or about 3 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a mixed loam varying from a black silty clay loam to a brown sandy loam. Occasionally small patches of peat are found. The sample taken contained about 4.8 percent of organic matter, or 48 tons per acre.

The subsurface is a brown mixed loam varying in physical composition the same as the surface. It contains, according to the sample, about 3 percent of organic matter.

The subsoil is a brownish silt to sandy loam, becoming lighter with increasing depth.

Management.—In the management of this type, good cultivation is about the only thing to be considered.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to intelligently interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification here used.

The unit in the soil survey is the soil type, and each type possesses more or less definite characteristics. The line of separation between adjoining types is usually distinct, altho sometimes one type grades into another so gradually that it is very difficult to draw the line between them. In such exceptional cases, some slight variation in the location of soil-type boundaries is unavoidable.

In establishing soil types several factors must be taken into account. These are: (1) the geological origin of the soil, whether residual, cumulose, glacial, eolial, alluvial, or colluvial; (2) the topography, or lay of the land; (3) the native vegetation, as prairie grasses or forest; (4) the depth and the character of the surface, the subsurface, and the subsoil, as to the percentages of gravel, sand, silt, clay, and organic matter which they contain, their porosity, granulation, friability, plasticity, color, etc.; (5) the natural drainage; (6) the agricultural value, based upon its natural productiveness; (7) the ultimate chemical composition and reaction.

Great Soil Areas in Illinois.—On the basis of the first of the above mentioned factors, namely, the geological origin, the state of Illinois has been divided into seventeen great soil areas with respect to their geological formation. The names of these areas are given in the following list along with their corresponding index numbers, the use of which is explained below. For the location of these geological areas, the reader is referred to the general map published in Bulletins 123 and 193.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* comprizing three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciations
300 *Lower Illinoisan glaciation,* covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* found in the older or Illinoisan glaciation
1400 *Late river-bottom and swamp lands,* those of the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan

Mechanical Composition of Soils.—The mechanical composition, or the texture, is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents:

Organic matter: undecomposed and partially decayed vegetable material
Inorganic matter: clay, silt, fine sand, sand, gravel, stones

Classes of Soils.—Based upon the relative proportion of the various constituents mentioned above, soils may be grouped into a number of well recognized classes. Following is a list of these classes, arranged according to their index numbers, the use of which is explained below:

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

Naming and Numbering Soil Types.—The naming of soil types has been the subject of much discussion, and practice varies considerably in this matter. In this soil survey of Illinois a system of classification and naming has been adopted which is based upon the various considerations presented in the preceding paragraphs.

After texture, one of the most striking characteristics of a soil is the color. Therefore, in the naming of soils in Illinois, a combination of color and texture, together with other descriptive terms when necessary, has been adopted so that the name in itself carries a definite description of a given soil type; as for example, "gray silt loam on tight clay," or "brown silt loam over gravel." The use of the prepositions *on* and *over* serves to indicate the presence of certain substrata. When the surface soil is underlain with material such as sand, gravel, or rock, the word *over* is used if this material lies at a depth greater than 30 inches; if it is less than 30 inches, the word *on* is used.

For further identification of soil types a system of numbering, resembling somewhat the Dewey library system, has been adopted whereby each soil type is assigned a certain number. This number indicates at once the geological origin of the soil as well as its physical description. The digits of the order of hundreds represent the geological area where the soil is found, beginning with 000, the residual, followed by 100, the unglaciated, and the rest of the series in the order of the enumeration presented in the paragraph above headed *Great Soil Areas in Illinois.* The digits of the orders of units and tens represent the various kinds of soil such as are enumerated above in the list of soil classes. Certain modifications are designated in this system by a figure placed at the right of the decimal point. To illustrate the working of this numbering system, suppose a soil type bears the number 726.5. The number 7 indicates that this soil occurs in the Iowan glaciation, the 26 that it is a brown silt loam, and the .5 that rock

is found less than 30 inches below the surface. These numbers are especially useful in designating small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports.

SOIL SURVEY METHODS

Mapping the Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. In order that the survey be thoroly trustworthy it is necessary that careful, well-trained men be employed to do the mapping. The work is prosecuted to the best advantage by working in parties of from two to four. Only such men are placed in charge of these parties as are thoroly experienced in the work and have shown themselves to be especially well qualified in training and ability.

The men must be able to keep their location exactly and to recognize the different soil types, with their principal variations and limits, and they must show these upon the maps correctly. A definite system is employed in checking up this work. As an illustration, one man will survey and map a strip 80 rods or 160 rods wide and any convenient length, while his associate will work independently on another strip adjoining this area, and if the work is correctly done the soil-type boundaries will match up on the line between the two strips.

An accurate base map for field use is absolutely necessary for soil mapping. The base maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as a basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil-type boundaries, together with the streams, roads, railroads, canals, and town sites are placed in their proper locations upon the map while the mapper is on the area. Each section, or square mile, is divided into 40-acre plots on the map, and the surveyor must inspect every ten acres and determine the type or types of soil thereon. The different types are indicated on the map by different colors, pencils for this purpose being carried in the field.

A small auger 40 inches long forms for each man an invaluable tool with which he can quickly secure samples of the different strata for inspection. An extension for making the auger 80 inches long is taken by each party, so that any peculiarity of the deeper subsoil layers may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by a speedometer or by some other measuring device, while distances in the field away from the roads are determined by pacing, an art in which the men become expert by practice. The soil boundaries can thus be located with as high a degree of accuracy as can be indicated by pencil on the scale of one inch to the mile.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. For this purpose usually three strata are sampled; namely, the surface (0 to 6⅔ inches), the subsurface (6⅔ to 20 inches), and the subsoil

(20 to 40 inches). These strata correspond approximately, in the common kinds of soil, to 2,000,000 pounds of dry soil per acre in the surface layer, and to two times and three times this quantity in the subsurface and the subsoil, respectively. This is, of course, a purely arbitrary division, very useful in arriving at a knowledge of the quantity and the distribution of plant food in the soil, but it should be noted that these strata do not necessarily coincide with the natural strata as they actually exist in the soil, and which are referred to in describing the soil types.

By this system of sampling we have represented separately three zones for plant feeding. The surface layer includes at least as much soil as is ordinarily turned with the plow. This is the part with which the farm manure, limestone, phosphate, or other fertilizer applied in soil improvement is incorporated, and which must be depended upon in large part to furnish the necessary plant food for the production of crops. A rich subsoil has little or no value if it lies beneath a worn-out surface, but if the fertility of the surface soil is maintained at a high point, then the strong vigorous plants will have power to secure more plant food from the subsurface and subsoil.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. Even tho plowed alike and at the same time, prepared the same way, planted the same day with the same kind of seed, and cultivated alike, watered by the same rains and warmed by the same sun, nevertheless the best acre may produce twice as large a crop as the poorest acre on the same farm, if not, indeed, in the same field; and the fact should be repeated and emphasized that with the normal rainfall of Illinois the productive power of the land depends primarily upon the stock of plant food contained in the soil and upon the rate at which it is liberated, just as the success of the merchant depends primarily upon his stock of goods and the rapidity of sales. In both cases the stock of any commodity must be increased or renewed whenever the supply of such commodity becomes so depleted as to limit the success of the business, whether on the farm or in the store.

CROP REQUIREMENTS

Ten different elements of plant food are essential for the growth and formation of every plant. These elements are: *carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, magnesium, calcium, and iron;* and they are represented by the chemical symbols: C, O, H, N, P, S, K, Mg, Ca, and Fe. Some seasons in central Illinois are sufficiently favorable to allow the production of at least 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. When such crops, growing under favorable climatic and cultural conditions and uninjured by disease or insect pests, are not produced the failure is due to unfavorable soil condition, which may result from poor drainage, poor physical condition, or from an actual deficiency of plant food.

Table A shows the plant-food requirements of some of our most common field crops with respect to the seven elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a

TABLE A.—PLANT FOOD IN WHEAT, CORN, OATS, AND CLOVER

Produce: Kind	Produce: Amount	Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain......	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat, straw.....	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain.......	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover.......	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs........	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain.......	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw........	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed.......	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay.......	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00

ton, as the case may be. From these data the amount of any element removed from an acre of land by a crop of a given yield can easily be computed.

It needs no argument to show that the continuous removal of such quantities of plant food without provision for their replacement must result sooner or later in soil depletion.

PLANT-FOOD SUPPLY

Of the ten elements of plant food, three (*carbon, oxygen,* and *hydrogen*) are secured from air and water, and seven from the soil. *Nitrogen,* one of these seven elements obtained from the soil by all plants, may also be secured from the

TABLE B.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure............................	10	2	8
Corn stover..................................	16	2	17
Oat straw....................................	12	2	21
Wheat straw..................................	10	2	19
Clover hay...................................	40	5	30
Cowpea hay...................................	43	5	33
Alfalfa hay..................................	50	4	24
Sweet clover (water-free basis)[1]............	80	8	28
Dried blood..................................	280	...	...
Sodium nitrate...............................	310	...	...
Ammonium sulfate.............................	400	...	...
Raw bone meal................................	80	180	...
Steamed bone meal............................	20	250	...
Raw rock phosphate...........................	...	250	...
Acid phosphate...............................	...	125	...
Potassium chlorid............................	...	...	850
Potassium sulfate............................	...	...	850
Kainit.......................................	...	...	200
Wood ashes[2].................................	...	10	100

[1]Young second year's growth ready to plow under as green manure.
[2]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

air by one class of plants (legumes), in case the amount liberated from the soil is insufficient; but even these plants (which include only the clovers, peas, beans, and vetches among our common agricultural plants) are dependent upon the soil for the other six elements (*phosphorus, potassium, magnesium, calcium, iron,* and *sulfur*), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to nearly 33,000 pounds. In like manner the phosphorus content varies from about 420 to 4,900 pounds, the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table B is presented for the purpose of furnishing information regarding the quantity of plant food contained in some of the materials most commonly used as sources of plant-food supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of fertility actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such plant foods as calcium and phosphorus, converting them into available forms of food for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral foods are liberated for the benefit of the less independent feeding cereal crops which follow in the rotation. Moreover, as an effect of the deep rooting habit of these legumes, large quantities of mineral plant foods are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and thus encourages the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the insoluble and unavailable organic nitrogen into soluble and available nitrate nitrogen. At the

same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium, and also to dissolve the insoluble phosphate and limestone which may be applied in low-priced forms. Thus, in the conversion of sufficient organic nitrogen into nitrate nitrogen for a 100-bushel crop of corn, the nitrous acid formed is alone sufficient to convert seven times as much insoluble tricalcium phosphate into soluble monocalcium phosphate as would be required to supply the phosphorus for the same crop.

Organic Matter and Biological Action.—Organic matter may be supplied by animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant food than the 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the *ratio of carbon to nitrogen.* Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing soluble phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant food by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant food is concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides the plant food calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by preventing the growth of certain fungus diseases, such as corn root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement.

Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands. Remarkable success has been experienced with limestone used in conjunction with sweet clover in the reclamation of abandoned hill land which had been ruined thru erosion.

Amounts to Apply.—If the soil is acid, usually at least 2 tons per acre of ground limestone should be applied as an initial treatment. Continue to apply limestone from time to time according to the requirement of the soil as indicated by the tests described below, or until the most favorable conditions are established for the growth of legumes, using preferably at times magnesian limestone ($CaCO_3MgCO_3$), which contains both calcium and magnesium and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone ($CaCO_3$). On strongly acid soils, or on land being prepared for alfalfa, 4 or 5 tons per acre of ground limestone may well be used for the first application.

How to Ascertain the Need for Limestone.—The need of a soil for limestone may be ascertained by applying one of the following tests for soil acidity. Along with the acidity test, a test for the presence of carbonates should be made. It should be understood that a positive test for carbonates does not guarantee the absence of acid; for it may happen, especially when the soil is near the neutral point, that positive tests for both acidity and carbonates are obtained. This condition is explained by the assumption that solid particles of calcium or magnesium carbonates form centers of alkalinity within a soil that is generally acid. Because of this fact any test made of a given soil ought to be repeated if it is to be thoroly reliable. It is also desirable to test samples from different depths. Following are the directions for making these tests:

The Litmus Paper Test for Acidity. Make a ball of fresh moist soil, break it in two, insert a piece of blue litmus paper, and press the soil firmly together. After a few minutes examine the paper. If it has turned pink or red, soil acidity is indicated. The intensity of the color and the rapidity with which it develops indicates to some extent the amount of acidity. Needless to say the reliability of the test depends upon the quality of litmus paper used.

The Potassium Thiocyanate Test for Acidity. A more recently discovered test for soil acidity which promises to be more satisfactory than the litmus test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol (not denatured). When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. The conditions for a prompt reaction require a temperature that is comfortably warm.

The Hydrochloric Acid Test for Carbonates. Make a shallow cup of a ball of soil and pour into it a few drops of concentrated hydrochloric acid. If carbonates are present they are decomposed with the liberation of carbon dioxid, which appears as gas bubbles, producing foaming or effervescence. With much carbonate present the action is lively, but with mere traces of it the bubbles are given off slowly. If no carbonate, or very little, is indicated by the test, then it is advisable to apply limestone.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for agricultural uses. *These are the chemical and the biological fixation of the atmospheric nitrogen.* Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of those legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for feed and seed as well as for nitrate production, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen, the possibilities of which now represent numerous compounds, will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes.

For easy figuring it may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpeas contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of a soil varies according to its origin and the kind of farming practiced. Even virgin soils are found that are deficient in phosphorus.

On all lands deficient in phosphorus (except on those susceptible to serious erosion by surface washing or gullying) that element should be applied in considerably larger amounts than are required to meet the actual needs of the crops desired to be produced. The abundant information thus far secured shows positively that finely ground natural rock phosphate can be used successfully and very profitably, and clearly indicates that this material will be the most economical form of phosphorus to use in all ordinary systems of permanent, profitable soil improvement. The first application may well be one ton per acre, and subsequently about one-half ton per acre every four or five years should be applied, at least until the phosphorus content of the plowed soil reaches 2,000 pounds per acre, which may require a total application of from 3 to 5 or 6 tons per acre of raw phosphate containing 12½ percent of the element phosphorus.

Steamed bone meal and even acid phosphate may be used in emergencies, but it should always be kept in mind that a pound of phosphorus delivered in Illinois in the form of raw phosphate (direct from the mine in carload lots), is much cheaper than the same amount in steamed bone meal or in acid phosphate, both of which cost too much per ton to permit their common purchase by farmers in carload lots, which is not the case with raw phosphate. Landowners should bear in mind the fact that phosphorus additions to the soil in amounts above the immediate crop requirements represent a permanent investment, since this element is not readily lost in the drainage water as in the case of nitrogen. It is removed from the farm thru the sale of crops, milk, and animals.

Phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

The Potassium Problem

Normal soils, in which clay and silt form a considerable part of the constituency, are well stocked with potassium, altho it exists largely in insoluble

form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be supplied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of normal soils are concerned, that the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part perhaps because the potassium removed in the crops is mostly returned in the manure if properly cared for, and perhaps in larger part because the decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no plant food of value.

In considering the conservation of potassium on the farm it should be remembered that in average live-stock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in live-stock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by the actual crop requirements for plant food, magnesium and calcium are more limited in some Illinois soils than potassium. But with these elements we must also consider the loss by leaching.

Doctor Edward Bartow and associates, of the Illinois State Water Survey, have shown that as an average of 90 analyses of Illinois well-waters drawn chiefly from glacial sands, gravels, or till, 3 million pounds of water (about the average

annual drainage per acre for Illinois) contained 11 pounds of potassium, 130 of magnesium, and 330 of calcium. These figures are very significant, and it may be stated that if the plowed soil is well supplied with the carbonates of magnesium and calcium, then a very considerable proportion of these amounts will be leached from that stratum. Thus the loss of calcium from the plowed soil of an acre at Rothamsted, England, where the soil contains plenty of limestone, has averaged more than 300 pounds a year as determined by analyzing the soil in 1865 and again in 1905. And practically the same amount of calcium was found by analyzing the Rothamsted drainage waters.

Common limestone, which is calcium carbonate ($CaCO_3$), contains, when pure, 40 percent of calcium, so that 800 pounds of limestone is equivalent to 320 pounds of calcium. Where 10 tons per acre of ground limestone was applied at Edgewood, Illinois, the average annual loss during the next ten years amounted to 790 pounds per acre. The definite data from careful investigations thus seem to indicate that where limestone is needed at least 2 tons per acre should be applied every four or five years.

It is of interest to note that thirty crops of clover of 4 tons each would require 3,510 pounds of calcium, while the most common prairie land of southern Illinois contains only 3,420 pounds of total calcium in the plowed soil of an acre. Thus limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals —to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of

sulfur, such as exists in our common types of soil, and an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply to conditions in Illinois.

Physical Improvement of Soils

In the management of most soil types, one very important thing, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is being destroyed during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, corn stalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and corn stalks should be turned under, and not burned. Probably no form of organic matter acts more beneficially in producing good tilth than corn stalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of corn stalks is one and one-half times that of a ton of manure, and a ton of dry corn stalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the corn stalks during the winter and often rather late in the spring after the frost is out of the ground. This tramping by stock sometimes puts the soil in bad condition for

working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The bad effect will be greater if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including a liberal use of legumes, in order to increase the organic matter of the soil either by plowing under the legume crops and other crop residues (straw and corn stalks), or by using for feed and bedding practically all the crops raised and returning the manure to the land with the least possible loss. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations, applicable to the corn belt, which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover), or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in live-stock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be seeded four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Wheat (with clover)
Second year —Corn
Third year —Oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields Representing the More Important Types of Soil Occurring in DeKalb County)

In the earlier reports of this series it was the practice to incorporate in the body of the report the results of certain experiment fields, for the purpose of illustrating the possibilities of improving the soil of various types. The information carried by such data must, naturally, be considered more or less tentative. As the fields grow older new facts develop, which in some instances may call for the modification of former recommendations. It has therefore seemed desirable to separate this experiment field data from the more permanent information of the soil survey, and embody the same in the form of a supplement to the soil report proper, thus providing a convenient arrangement for possible future revisions as additional data accumulate.

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the summarized results from certain of these fields which are representative of the types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement

These fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, live-stock farming and grain farming.

In the live-stock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in form of plant manures, including all the plant residues produced, such as corn stalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It is the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the live-stock system.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations, and on most of the fields provision is made so that every crop in the rotation is represented every year. The most common rotation used is wheat,

corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. In the event of clover failure, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, in large part, been standardized according to a rather definite system, altho many deviations from this system occur.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—All crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The usual yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, the equivalent of 200 pounds of kainit. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

BROWN SILT LOAM

Several experiment fields have been conducted on brown silt loam soil at various locations in Illinois. Those located at the University have been in operation the longest and they serve well to illustrate the principles involved in the maintenance and improvement of this type of soil.

The Morrow Plots

It happens that the oldest soil experiment field in the United States is located on typical brown silt loam of the early Wisconsin glaciation, on the campus of the University of Illinois. This field was started in 1879 by George E. Morrow, who for many years was Professor of Agriculture, and these plots are known as the Morrow plots.

The Morrow series now consists of three plots divided into halves and the halves are subdivided into quarters. On one plot corn is grown continuously; on the second, corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904, receiving standard applications of farm manure with cover crops grown in the one-crop and two-crop systems. Phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. At the same time the rate of subsequent application of both forms of phosphorus was reduced to one-fourth the quantity, or to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per year. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre with the intention of standardizing the application to the rate of 1,000 pounds of limestone per acre per year.

Table 1 gives the yearly record of the crop yields, and Table 2 presents the same in summarized form.

FIG. 1.—CORN ON THE MORROW PLOTS IN 1910

TABLE 1.—URBANA FIELD, MORROW PLOTS: BROWN SILT LOAM; PRAIRIE; EARLY WISCONSIN GLACIATION

Crop Yields in Soil Experiments—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
		Corn	Corn	Oats	Corn	Oats	Clover
1879–87	None........	....	....	....	....	....	....
1888	None........	54.3	49.5	....	....	48.6	....
1889	None........	43.2	....	37.4	....	....	(4.04)
1890	None........	48.7	54.3	....	....	....	(1.51)
1891	None........	28.6	33.2	....	....	....	(1.46)
1892	None........	33.1	....	37.2	70.2	....	....
1893	None........	21.7	29.6	....	34.1	....	....
1894	None........	34.8	....	57.2	....	65.1	....
1895	None........	42.2	41.6	....	....	22.2	....
1896	None........	62.3	....	34.5	....	....	....
1897	None........	40.1	47.0	....	....	....	....
1898	None........	18.1	....	....	....	....	....
1899	None........	50.1	44.4	....	53.5	....	....
1900	None........	48.0	....	41.5	....	....	....
1901	None........	23.7	33.7	....	34.3	....	....
1902	None........	60.2	....	56.3	....	54.6	....
1903	None........	26.0	35.9	....	....	....	(1.11)
1904	None........	21.5	....	17.5	55.3	....	....
1904	MLP........	17.1	....	25.3	72.7	....	....
1905	None........	24.8	50.0	....	....	42.3	....
1905	MLP........	31.4	44.9	....	....	50.6	....
1906	None........	27.1	....	34.7	....	....	(1.42)[1]
1906	MLP........	35.8	....	52.4	....	....	(1.74)[1]
1907	None........	29.0	47.8	....	80.5	....	....
1907	MLP........	48.7	87.6	....	93.6	....	....
1908	None........	13.4	....	32.9	....	40.0	....
1908	MLP........	28.0	....	45.0	....	44.4	....
1909	None........	26.6	33.0	....	....	....	(.65)[2]
1909	MLP........	31.6	64.8	....	....	....	(1.73)[3]
1910	None........	35.9	....	33.8	58.6	....	....
1910	MLP........	54.6	....	59.4	83.3	....	....
1911	None........	21.9	28.6	....	....	20.6	....
1911	MLP........	31.5	46.3	....	....	38.0	....
1912	None........	43.2	....	55.0	....	....	16.3[1]
1912	MLP........	64.2	....	81.0	....	....	20.0[1]
1913	None........	19.4	29.2	....	33.8	....	....
1913	MLP........	32.0	25.0	....	47.8	....	....
1914	None........	31.6	....	33.6	....	39.6	....
1914	MLP........	39.4	....	58.2	....	60.4	....
1915	None........	40.0	49.0	....	....	....	24.2[1]
1915	MLP........	66.0	81.2	....	....	....	27.1[1]
1916	None........	11.2	....	37.5	27.8	....	....
1916	MLP........	10.8	....	64.7	40.6	....	....
1917	None........	40.0	48.4	....	....	68.4	....
1917	MLP........	78.0	81.4	....	....	86.9	....
1918	None........	13.6	....	27.2	....	....	(2.58)
1918	MLP........	32.6	....	59.3	....	....	(4.04)
1919	None........	24.0	30.8	....	52.2	....	....
1919	MLP........	43.4	66.2	....	70.8	....	....
1920	None........	28.2	....	37.2	....	52.2	....
1920	MLP........	54.4	....	51.6	....	69.7	....
1921	None.......	19.8	30.6	....	....	....	(.26)[4]
1921	MLP.......	42.2	68.4	...	....	....	(1.33)[5]

[1]Soybeans.
[2]In addition to the hay, .64 bushel of seed was harvested.
[3]In addition to the hay, 1.17 bushels of seed were harvested.
[4]In addition to the hay, .53 bushel of seed was harvested.
[5]In addition to the hay, .85 bushel of seed was harvested.

TABLE 2.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY
Average Annual Yields—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover
		16 crops	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
1888 to 1903	None........	39.7	41.0	44.0	48.0	47.6	(2.03)
		18 crops	*9 crops*	*9 crops*	*6 crops*	*6 crops*	*4 crops*
1904 to 1921	None........	26.2	38.6	34.4	51.4	43.9	(1.23)[1]
	MLP........	41.2	62.9	55.2	68.1	58.3	(2.21)[1]

[1]One crop of soybean hay.

Summarizing the data from these Morrow plots into two periods with the second period beginning in 1904 when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oats production, while the averages for the three-year system show an increase in corn yield and decreases in oats and clover. Unfortunately the numbers of crops included in these last averages are too small to warrant positive conclusions.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

The Davenport Plots

Another set of plots on the University campus at Urbana, forming a more extensive series than the Morrow plots, but of more recent origin, are the Davenport plots. Here each crop in the rotation is represented every year. These plots were laid out in 1895, but special soil treatment was not begun until 1901. They now comprize five series of ten plots each, and each series constitutes a "field" in a crop rotation system.

From 1901 to 1911 three of the series were in a three-year rotation system of corn, oats, and clover, while the remaining two series rotated in corn and oats. In 1911 these two systems were combined into a five-series field, with a crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field. The alfalfa occupies one series during a rotation of the other four crops, shifting to another series in the fifth year, thus completing the cycle of all series in twenty-five years.

The soil treatment applied to these plots has been as follows:

Legume cover crops were seeded in the corn at the last cultivation on Plots 2, 4, 6, and 8, from 1902 to 1907, but the growth was small and the effect, if any, was to decrease the returns from the regular crops. Crop residues (**R**) have been returned to these same plots since 1907. These consist of stalks and straw, and all legumes except alfalfa hay and the seed of clover and soybeans. Beginning in 1918 a modification of the practice was made in that one cutting of the red clover crop is harvested as hay. In conjunction with these residues a catch crop of sweet clover grown with the wheat is plowed under.

Manure (**M**) was applied preceding corn, at the rate of 2 tons per acre per year in 1905, 1906, and 1907; subsequently as many tons have been applied as there have been tons of air-dry produce harvested from the respective plots.

Lime (**L**) was applied on Plots 4 to 10 at the rate per acre of 250 pounds of air-slaked lime in 1902, and 600 pounds of limestone in 1903. No further application was made until 1911, when the system of cropping was changed. Since that time applications of limestone have been made at the rate of one-half ton per acre per year.

Phosphorus (**P**) was applied on Plots 6 to 9 at the rate of 25 pounds per acre per annum in 200 pounds of steamed bone meal; but beginning with 1908 rock phosphate at the rate of 600 pounds per acre per annum was substituted for the bone meal on one-half of each of these plots. These applications continued until 1918 when adjustments were begun, first to make the rate of application of rock phosphate four times that of the bone meal, and finally to reduce the amounts of these materials to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per annum. The usual practice has been to apply and plow under at one time all phosphorus and potassium required for the rotation.

Potassium (**K** = kalium) has been applied on Plots 8 and 9, in connection with the organic manures and phosphorus, at the yearly rate of 42 pounds per acre, and mainly as potassium sulfate.

On Plot 10 about five times as much manure and phosphorus are applied as on the other plots, but this "extra heavy" treatment was not begun until 1906, only the usual amounts of lime, phosphorus, and potassium having been applied in previous years. The purpose in making these heavy applications is to try to determine the climatic possibilities in crop yields by removing the limitations of inadequate fertility.

It will be observed that the applications described above provide for the two rather distinct systems of farming already described. *The grain system,* in which animal manure is not produced and where the organic matter is provided by the direct return to the soil of all crop residues along with legumes, is exemplified in Plots 2, 4, 6, and 8; and the *live-stock system,* in which farm manure is utilized for soil enrichment, is represented in Plots 3, 5, 7, and 9.

Table 3 shows a summary of the results obtained on the Davenport plots beginning with the year 1911, when the present cropping system was introduced.

When used in conjunction with phosphorus the crop residues and the manure appear about equally effective; but where phosphorus is not applied, the manure has been decidedly more effective, under the conditions of the experiment. It should be observed, however, in this connection, that the plowing under of clover is a very essential feature of the residues system, and that, as a matter of fact, there were five clover failures, when soybeans were substituted, during the ten years. Perhaps with a more reliable biennial legume than red clover, the results would have been more favorable for this system.

By comparing Plots 2 and 3 with Plots 4 and 5, it is found that limestone has had a beneficial effect on all crops. What the financial profit amounts to depends obviously upon the market value of the crops and the cost of the limestone.

TABLE 3.—URBANA FIELD, DAVENPORT PLOTS: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre
1911–1920

Serial plot No.	Soil treatment applied	Corn	Oats	Wheat	Clover 5 crops	Soybeans 5 crops	Alfalfa
1	0..............	55.6	50.5	26.0	(2.42)	(1.47)	(2.43)
2	R..............	57.1	52.3	28.7	1.47[1]	19.8	(2.46)
3	M..............	66.3	61.9	28.2	(2.56)	(1.62)	(2.52)
4	RL............	64.8	55.6	31.4	1.61[1]	20.3	(2.72)
5	ML............	69.6	64.1	32.8	(2.90)	(1.67)	(3.03)
6	RLP...........	71.5	69.8	43.0	2.29[1]	23.5	(3.69)
7	MLP...........	73.0	68.6	40.0	(3.52)	(1.97)	(3.76)
8	RLPK.........	70.9	72.5	40.7	1.79[1]	25.5	(3.77)
9	MLPK.........	70.2	72.0	39.2	(3.40)	(2.20)	(3.73)
10	Mx5LPx5.......	65.9	71.4	40.6	(3.31)	(2.22)	(3.77)

[1]In addition to the clover seed, a crop of hay was harvested one year on Plots 2, 4, 6, and 8, yielding 2.38, 2.20, 2.54, and 2.39 tons respectively.

Comparing Plots 4 and 5 with Plots 6 and 7, respectively, there is found in all cases an increase in crop yield as a result of adding phosphorus. The effect on wheat is especially pronounced. Where limestone and phosphorus are applied in addition to the crop residues, an increase of 17 bushels of wheat, over the yield of the untreated land, has been obtained as a ten-year average.

Manure
Yield: 1.43 tons per acre

Manure, limestone, phosphorus
Yield: 2.90 tons per acre

FIG. 2.—CLOVER ON THE DAVENPORT PLOTS IN 1913

The effect of adding potassium to the treatment is of much interest. Plots 8 and 9 are the same as Plots 6 and 7, respectively, except that potassium has been applied to the former. On the whole, no significant benefit is shown from the addition of potassium.

No benefit appears as the result of the extra-heavy applications of manure and phosphorus on Plot 10. In fact the corn yields are noticeably less here than on the plots receiving the normal applications of these materials.

The University South Farm

On the University South Farm, at Urbana, several series of plots devoted primarily to variety testing and other crop-production experiments are so laid out as to show the effects of certain soil treatments that have been applied. Several different systems of crop rotation are employed and the crops are so handled as to exemplify the two general systems of farming, grain and live-stock.

The summarized results presented in Table 4 represent three different systems of cropping. The first, designated as the Southwest rotation, is to be regarded as a good rotation for general practice, on this type of soil, under Illinois conditions. This is a four-field rotation of wheat, corn, oats, and clover.

TABLE 4.—URBANA FIELD, SOUTH FARM: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre
1908-1919

Southwest Rotation: Series 100, 200, 400[1]: Wheat, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 9 crops	Oats[3] 9 crops	Wheat[3] 8 crops	Clover[4] 3 crops	Soybeans 7 crops
RP	62.3	51.9	41.0	1.05	17.3[5]
R	51.9	46.5	26.9	1.38	16.2[5]
M	59.7	50.2	29.1	(2.28)	(1.25)
MP	64.3	55.4	43.1	(2.86)	(1.51)
RLP	60.5	57.2	41.8	.64	16.4[5]
R	49.7	49.6	25.8	.83	14.7[5]
M	55.5	54.1	27.8	(1.71)	(1.28)
MLP	64.1	59.6	43.9	(1.77)	(1.58)

North-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Oats 9 crops	Clover 5 crops	Soybeans 4 crops
RP	56.7	51.1	56.1	.54	16.9
R	51.7	45.2	52.0	.50	16.0
M	54.9	46.7	52.1	(2.29)	(1.60)
MP	56.5	53.4	56.9	(2.73)	(1.74)

South-Central Rotation: Series 500, 600, 700[1]: Corn Corn, Corn, Soybeans

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Corn 3d year 9 crops		Soybeans 9 crops
RP	51.9	44.0	41.3		20.0
R	45.5	39.9	35.2		19.2
M	50.1	42.1	33.5		(1.59)
MP	54.5	46.7	42.0		(1.66)

[1]Results from Series 300 and 800 are omitted on account of variation in soil type.
[2]Soybeans when clover fails.
[3]Only seven crops with limestone.
[4]Only one crop with limestone.
[5]Average of five crops.
[6]All phosphorus plots received ½ ton per acre of limestone in 1903.

TABLE 5.—COMPARING PRODUCTION OF CORN IN THREE DIFFERENT ROTATION SYSTEMS
YIELDS FROM PLOTS ON THE UNIVERSITY SOUTH FARM

Twelve-Year Average (1908–1919)—Bushels per acre

Rotation	Wheat-corn-oats-legume[1]	Corn-corn-oats-legume[2]		Corn-corn-corn-legume[3]		
Treatment	Corn	1st Corn	2d Corn	1st Corn	2d Corn	3d Corn
Organic manures	55.8	53.3	46.0	47.8	41.0	34.3
Organic manures, phosphorus	63.2	56.6	52.3	53.2	45.3	41.6

[1]Clover 3 crops and soybeans 7 crops.
[2]Clover 5 crops, and soybeans 5 crops.
[3]Soybeans 9 crops.

The second, or North-Central rotation, consisting of corn, corn, oats, and clover, represents a system very commonly practiced; and the third or South-Central rotation, consisting of corn, corn, corn, and soybeans, must be considered as a poor rotation from the standpoint of maintaining the productiveness of the land.

On the whole, the "residues" have not returned yields quite so high as those produced by the manure treatment; but, as remarked above in the discussion of the Davenport plots, the residues system has probably been at a disadvantage thru frequent clover failures. On the North-Central rotation, where conditions seem to have been more favorable for clover, there is very little difference between the effect of manure and of residues.

Residues plowed under
Yield: 35.2 bushels per acre

Residues and rock phosphate
Yield: 50.1 bushels per acre

FIG. 3.—WHEAT ON THE UNIVERSITY SOUTH FARM IN 1911

In the rotation system in which limestone is being applied, no benefit of consequence to any of the crops except oats appears from the use of this material. The test, however, has hardly been of sufficient duration to warrant final conclusions; and furthermore, the comparison may be somewhat impaired by a possible residual effect of the small application of limestone made in 1903 to all the phosphorus plots.

The results obtained from the use of phosphorus are important because this element has been applied to these plots solely in the form of raw rock phosphate. The figures in almost every case show an increase in yield where the phosphorus has been applied, and in most cases this increase is very pronounced. The wheat is especially responsive to phosphorus.

The records furnish some interesting comparisons of corn yields produced under different systems of cropping. Table 5 gives a general summary of the corn yields only, in which the results from the residues and manure treatments are averaged together as "organic manures." The highest annual acre-yields are found where corn occurs but once in a rotation. Where corn is grown twice in succession, the annual acre-yields are less; and where corn occurs three times, there is a further reduction. Also, the first crop of corn within a rotation produces more than the second, and the second crop yields more than the third. These are useful facts for consideration in connection with problems of general farm management.

The DeKalb Field

An experiment field located in DeKalb county on the brown silt loam type of soil, just south of the city of DeKalb, has been in operation since 1906. This field was established primarily as a crops experiment field where the investigations relate to such matters as methods of seeding, cultivation, care, handling, and tests of varieties of our common field crops. Incidentally, however, the effects of certain soil treatments on these plots are compared. It is the present purpose to consider only those results that have to do directly with these soil treatments. The results of the strictly crops experiments are presented from time to time in other appropriate bulletins.

The diagram presented as Fig. 4 shows the arrangement of the plots, the system of numbering, the plan of soil treatment, and the cropping systems employed.

Arrangement of Plots.—The plots lie in four series, which number in hundreds from north to south. Each series has two divisions, an east and a west. Each division consists of 18 plots. These plots number from west to east according to the system indicated in the diagram on the 100 series. The plots of the 100 series are one-tenth acre in size, while those on the other series are one-fifth acre.

Standard Plots.—All plots corresponding to the numbers 3, 6, 9, 10, 13, and 16 are called standard plots; that is, the variety, or whatever the test may be aside from soil treatment, is alike on all of these six plots for any one division.

Soil Treatment.—In order to maintain the productiveness of the field, fertilizing materials are applied and definite systems of crop rotation are employed

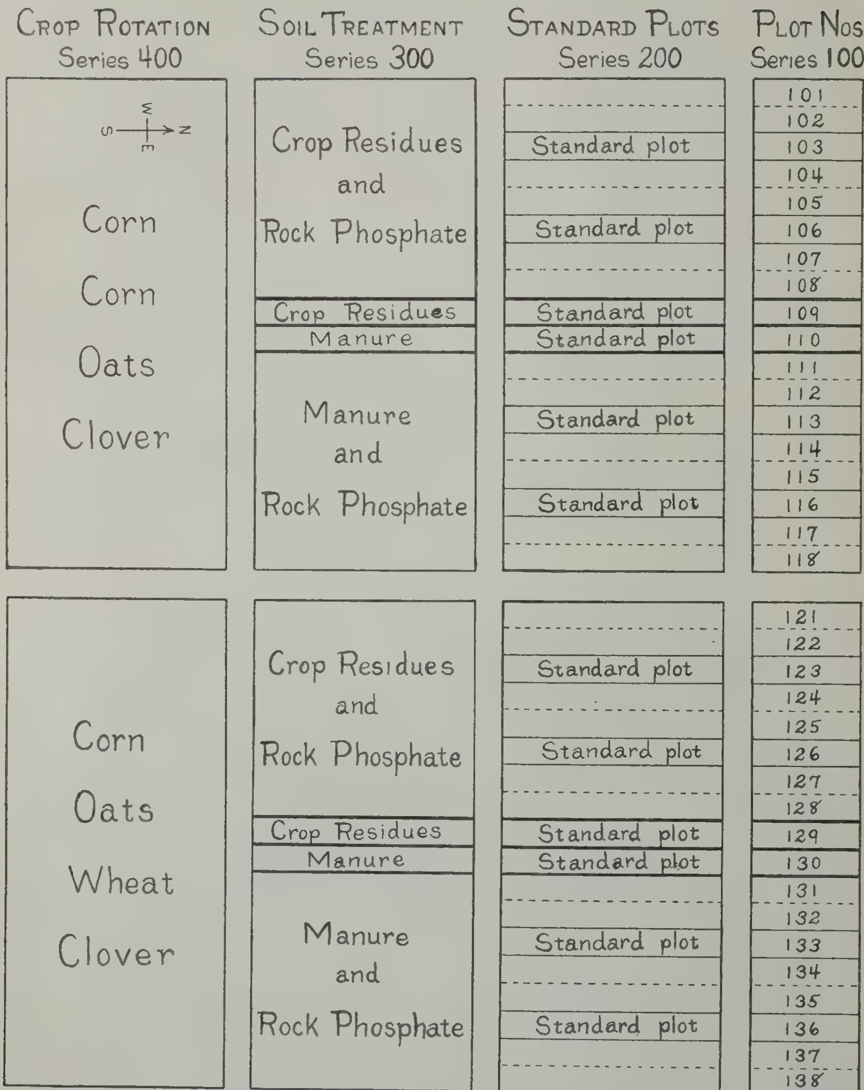


FIG. 4.—DIAGRAM OF DEKALB EXPERIMENT FIELD, SHOWING THE ARRANGEMENT OF PLOTS, THE SYSTEMS OF CROPPING, AND THE TREATMENTS APPLIED

as explained below, the crops being handled so as to exemplify the two systems of farming, grain and live stock. The plots comprizing the west half of each division represent grain farming. They receive no farm manure, but residues are returned to the soil. On the east half of each division, live-stock farming is represented, and here farm manure is applied in proportion to the crops produced. Raw rock phosphate is applied to all plots except the soil check plots (Nos. 9 and 10).

Soil Check Plots.—In the middle of every division two plots corresponding to the numbers 9 and 10 serve as check plots to test the effect of the phosphorus treatment. Plot 9 receives the crop residues produced and Plot 10 receives stable manure. Neither of these plots receives phosphate.

Rotation Systems.—The west half of the field, embracing the four west divisions of all four series, is farmed under a rotation of corn, corn, oats, and alsike clover. The east divisions of the series are in a rotation of corn, oats, wheat, and alsike clover. In the event of clover failure soybeans are substituted.

Tables 6 and 7 show the yield of each crop since the beginning of the experiments, and Table 8 gives a summary of these results, exclusive of those obtained in the beginning before full treatment was under way. Because of certain abnormalities in Plots 116 and 123 the data from these plots are excluded from the summary.

In looking over these records the beneficial effects of farm manure stand out prominently, thus emphasizing the importance of carefully conserving and regularly applying all available animal manures. Perhaps the fact next in interest to be noted is that the residues plots, with phosphorus applied, have returned yields almost as high as those from the manure plots. In considering this comparison it should be borne in mind that on these manure plots farm manure has been applied regularly at the rate of about 9 tons per acre every rotation, a practice quite impossible to carry out on every farm. It is possible, however, on every farm to sow clover and to return to the land the unconsumed crop residues, and this is the recourse for the farmer who cannot obtain animal manures in quantities sufficient to meet the demand of the land.

The profitable use of rock phosphate has been thoroly demonstrated on many farms in DeKalb county and if it seems surprising on first view that this material has not given greater returns on the DeKalb experiment field than the records show, the reader should take into full account the conditions involved as explained below.

In considering the results for rock phosphate on the DeKalb field, it should be explained at the outset that the soil of this field is considerably richer in phosphorus than the average brown silt loam, the analysis showing over 1,600 pounds per acre of this element in the surface stratum. A study of the summarized data shows some gain for rock phosphate in every crop excepting the clover seed in one of the crop rotation systems. In general these gains are more pronounced in the residues system than where applied with animal manure, which is not surprising since the manure itself carries back to the land a large share of the phosphorus removed in the grain.

It is to be observed further that phosphorus has been more effective in that rotation system which includes corn, oats, wheat, and clover than in the one

TABLE 6.—DEKALB FIELD: BROWN SILT LOAM PRAIRIE; EARLY WISCONSIN GLACIATION
ROTATION: CORN, OATS, WHEAT, CLOVER
Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1906 Corn	1907 Oats	1908 Wheat	1909 Clover	1910 Corn	1911 Oats	1912 Oats	1913 Clover	1914 Corn	1915 Oats	1916 Wheat	1917 Clover	1918 Corn	1919 Oats	1920 Wheat
123	RP.......	67.4	30.0	27.7	0.00	48.2	15.0	42.3	0.00	81.5	49.8	35.2	0.00	58.8	47.7	31.8
126	RP.......	92.8	35.6	38.5	0.00	70.9	12.2	41.1	0.00	84.1	51.2	43.4	0.00	62.0	45.5	31.8
129	R........	67.3	33.4	37.3	0.00	63.9	18.1	55.9	0.00	61.3	40.7	35.1	0.00	57.2	41.4	26.6
130	M........	69.3	33.8	33.0	(.60)	61.1	17.6	64.6	(.92)	69.4	26.9	29.3	(.92)	57.3	41.1	28.5
133	MP......	76.8	39.1	43.0	(.90)	61.5	19.7	72.9	(1.96)	79.0	33.1	29.9	(.85)	57.0	38.8	36.8
136	MP......	72.0	35.0	41.8	(.90)	57.9	14.0	78.1	(1.96)	77.7	36.9	28.0	(.81)	57.0	42.7	36.8
		Oats	Wheat	Clover	Corn	Oats	Wheat	Soy-beans	Corn	Oats	Wheat	Clover	Corn	Oats	Wheat	Clover
223	RP.......	22.9	18.6	(2.92)	64.2	71.0	29.0	0.00	55.4	47.4	39.9	0.00	17.4	63.0	19.3	.50
226	RP.......	26.1	19.0	(2.90)	76.8	74.0	33.0	0.00	52.7	50.4	42.7	0.00	17.0	66.3	20.4	.70
229	R........	24.1	14.6	(2.32)	59.8	76.2	25.9	0.00	59.0	44.6	39.0	0.00	8.8	71.8	17.3	.90
230	M........	26.4	19.3	(2.55)	70.2	81.0	34.8	(1.40)	63.3	45.4	39.2	(2.25)	16.7	73.9	19.6	(2.30)
233	MP......	38.0	20.7	(2.67)	75.5	80.3	37.0	(1.40)	68.3	49.2	45.0	(2.56)	23.1	61.2	19.8	(2.46)
236	MP......	36.9	22.7	(2.45)	72.0	79.5	36.7	(1.90)	65.4	45.7	38.6	(2.56)	27.6	69.6	26.0	(2.24)
		Oats	Clover	Corn	Oats	Wheat	Clover	Corn	Oats	Wheat	Clover	Corn	Oats	Wheat	Clover	Corn
323	RP.......	27.9	(1.66)	55.9	70.1	31.2	0.00	67.2	57.4	39.0	0.00	48.6	87.0	24.4	2.91	56.0
326	RP.......	24.9	(1.66)	59.6	65.4	33.4	0.00	66.8	64.1	41.0	0.00	46.8	85.9	26.3	2.67	56.0
329	R........	25.4	(1.30)	39.2	73.3	25.6	0.00	54.4	54.0	25.4	0.00	38.5	80.7	21.1	2.50	43.4
330	M........	26.1	(1.30)	75.4	68.4	38.9	(.80)	69.9	66.4	33.5	(1.92)	50.7	77.1	20.4	(1.76)	61.4
333	MP......	22.8	(1.90)	67.1	74.6	39.0	(1.46)	67.9	71.9	37.2	(2.19)	52.6	78.3	22.2	(1.97)	57.4
336	MP......	23.6	(1.90)	72.6	67.3	45.9	(1.46)	66.8	71.7	39.5	(2.19)	54.7	74.5	29.0	(1.90)	57.4
		Soy-beans[1]	Corn	Oats	Oats	Clover	Corn	Oats	Wheat	Clover	Corn	Oats	Wheat	Clover	Corn	Oats
423	RP.......	....	43.9	36.2	61.4	0.00	81.0	81.3	35.4	3.29	32.4	68.8	25.4	1.24	70.1	80.7
426	RP.......	....	45.3	31.7	59.4	0.00	80.0	77.6	33.1	3.29	38.7	64.8	30.7	1.28	73.3	80.7
429	R........	....	43.5	37.3	66.1	0.00	76.4	77.8	27.7	4.50	30.9	62.5	25.2	1.33	62.3	68.8
430	M........	....	58.1	42.8	72.3	(3.10)	76.8	75.0	36.0	(2.68)	42.4	66.5	25.4	(2.21)	68.5	82.7
433	MP......	....	50.9	43.9	69.4	(3.08)	83.5	75.0	41.2	(3.05)	39.4	71.6	33.6	(2.68)	74.9	83.6
436	MP......	....	50.8	41.2	59.5	(3.08)	86.7	71.3	37.2	(3.05)	47.1	73.7	34.7	(2.56)	71.4	83.6

[1]Yields not taken.

TABLE 7.—DEKALB FIELD: BROWN SILT LOAM PRAIRIE; EARLY WISCONSIN GLACIATION
ROTATION: CORN, CORN, OATS, CLOVER
Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1906 Corn	1907 Corn	1908 Oats	1909 Clover	1910 Corn	1911 Corn	1912 Oats	1913 Clover	1914 Corn	1915 Corn	1916 Oats	1917 Clover	1918 Corn	1919 Corn	1920 Oats
103	RP.......	74.8	33.0	44.1	0.00	58.9	62.4	76.6	0.00	69.6	37.8	68.4	0.0	51.7	56.2	49.5
106	RP.......	76.2	37.8	40.9	0.00	62.4	64.1	76.1	0.00	78.3	39.7	63.9	0.0	57.9	64.1	49.5
109	R........	73.0	35.3	44.1	0.00	55.7	54.5	63.1	0.00	68.4	33.3	62.1	0.0	47.1	56.1	50.2
110	M........	72.8	35.5	40.6	(1.80)	54.2	56.0	66.2	(1.26)	78.7	30.4	69.1	(.79)	55.0	52.8	63.8
113	MP......	66.0	30.4	45.6	(2.40)	58.6	59.3	74.1	(1.74)	76.9	39.6	66.6	(.59)	53.2	64.1	66.1
116[1]	MP......	51.6	0.0	28.1	(2.00)	45.2	0.0	60.5	(1.74)	79.7	33.3	54.4	(.52)	62.9	64.6	66.1
		Corn	Oats	Clover	Corn	Corn	Oats	Soy-beans	Corn	Corn	Oats	Clover	Corn	Corn	Oats	Clover
203	RP.......	64.6	28.1	(2.45)	56.8	48.4	38.6	(.45)	58.3	50.4	68.5	0.00	17.2	51.3	62.1	2.90
206	RP.......	66.6	28.7	(2.87)	47.1	45.2	39.2	(.90)	61.2	58.0	69.2	0.00	16.0	48.5	53.3	3.70
209	R........	76.4	30.3	(2.40)	59.2	53.9	37.8	(1.20)	68.4	64.9	61.4	0.00	16.9	46.3	60.1	2.80
210	M........	72.4	29.0	(2.60)	68.5	56.8	37.8	(1.10)	63.0	65.6	57.5	(1.84)	21.3	48.6	57.1	(1.94)
213	MP......	45.4	28.1	(2.25)	66.5	52.7	26.9	(0.00)[2]	64.1	62.8	54.0	(1.82)	19.4	46.0	52.7	(1.84)
216	MP......	76.0	28.9	(2.32)	63.0	46.4	27.0	(0.00)[2]	58.8	62.5	64.6	(1.82)	22.2	43.5	49.9	(1.67)
		Oats	Clover	Corn	Corn	Oats	Clover	Corn	Corn	Oats	Clover	Corn	Corn	Oats	Soy-beans	Corn
303	RP.......	23.6	(1.38)	66.1	55.1	68.3	0.00	63.7	54.4	53.2	2.00	46.1	11.3	83.5	15.9	49.1
306	RP.......	21.9	(1.38)	67.8	58.2	84.5	0.00	68.0	60.1	49.1	2.00	44.6	13.9	70.9	17.2	52.7
309	R........	25.3	(1.25)	66.0	58.2	76.1	0.00	57.6	59.1	47.7	3.70	43.4	9.0	79.7	16.9	46.0
310	M........	24.9	(1.45)	73.3	55.4	71.9	(1.30)	63.7	60.0	42.5	(1.59)	51.6	7.3	77.7	(1.26)	58.6
313	MP......	24.6	(1.69)	69.2	52.8	80.9	(1.50)	83.1	53.4	43.2	(1.88)	53.0	11.2	74.9	(1.28)	88.6
316	MP......	23.7	(1.69)	70.8	54.5	82.7	(1.50)	78.2	55.3	43.4	(1.88)	47.0	8.8	73.0	(1.54)	60.8
		Cow-peas[3]	Corn	Corn	Oats	Clover	Corn	Corn	Oats	Clover	Corn	Corn	Oats	Clover	Corn	Corn
403	RP.......	....	53.0	43.9	37.5	0.00	78.6	52.4	43.2	3.12	40.5	40.3	67.5	1.49	56.6	44.9
406	RP.......	....	54.9	46.5	43.8	0.00	75.8	60.2	43.6	3.12	44.0	45.7	78.6	1.42	55.4	50.1
409	R........	....	47.7	30.9	50.8	0.00	49.7	39.5	33.6	1.29	26.5	37.9	67.6	.61	48.7	42.6
410	M........	....	65.8	50.9	60.1	(2.44)	63.1	56.7	39.7	(2.54)	35.9	42.2	85.3	(1.51)	62.3	52.7
413	MP......	....	73.5	55.1	69.0	(3.41)	73.7	67.7	51.1	(3.32)	37.5	47.8	94.2	(1.96)	53.8	62.9
416	MP......	....	74.3	54.3	67.3	(3.41)	72.3	62.4	54.7	(3 32)	44 4	45.4	93.1	(1.83)	53.6	59.9

[1]Alkali spot. [2]Growth practically all weeds. [3]Yields not taken.

TABLE 8.—DE KALB FIELD: SUMMARY

Average Annual Yields—Bushels or (tons) per acre
1909–1920

Soil treatment applied	Crop rotation: corn, oats, wheat, clover				Crop rotation: corn, corn, oats, clover			
	Corn	Oats[1]	Wheat[2]	Clover[3]	Corn	Corn	Oats	Clover[3]
Residues, phos.	59.8	59.9	32.7	0.66	54.6	48.9	59.9	1.02
Residues	51.3	59.4	26.9	0.77	49.0	46.3	57.5	.94
Manure, phos.	61.7	62.4	34.7	(2.05)	59.0	50.9	63.2	(1.81)
Manure	59.0	61.4	30.6	(1.74)	56.3	48.7	60.7	(1.61)

[1]Average of 14 crops, oats being substituted when wheat failed.
[2]Average of 10 crops, oats being substituted when wheat failed.
[3]Soybean hay reckoned as equivalent to clover hay; soybean seed reckoned at 1/10 the equivalent of clover seed.

consisting of corn, corn, oats, and clover. In the former cropping system rock phosphate has returned a good financial profit reckoned at the prices prevailing during the years in which these results were obtained. In the latter rotation system, however, in which wheat does not appear, the gain from the increases in yield due to phosphate is just about offset by the expense involved. When considered from the standpoint of permanent fertility, however, the fact should not be overlooked that, in either system, thru the phosphate applications, the soil has not only been protected from loss of phosphorus in crops removed, but it has actually been enriched in this element by the excess provided in the liberal amount of phosphate used.

On the whole these results are of interest in indicating that there may exist here and there an exceptional spot of brown silt loam which, under all circumstances, will not respond in the usual striking manner to phosphorus treatment. In such an instance perhaps the more economical procedure would be to defer for a time phosphorus treatment in favor of more urgent needs of the land without ignoring the fact, however, that the time will inevitably come when the supply of phosphorus will become depleted unless timely provision be made for the replenishment of this element.

YELLOW-GRAY SILT LOAM

Yellow-gray silt loam exhibits an important variation with respect to limestone content. In some areas, altho limestone may be altogether absent in the surface stratum it is found in abundance at a short distance beneath the surface. Accordingly, variations in response to soil treatment are exhibited by different experiment fields located on this type. In view of this discrepancy it is thought well to introduce here the records of two fields, that are representative of the type but which show a marked diversity in results, one in northern Illinois and one in the southern part of the state.

The Antioch field is located on the late Wisconsin glaciation, in Lake county, close to the Wisconsin border. The field was started in 1902, with but a single series of ten plots, under a rotation of corn, corn, oats, and wheat; but beginning with 1911 the rotation has been wheat, corn, oats, and clover. It was started in order to learn as quickly as possible what effect would be produced by the addition to this type of soil of nitrogen, phosphorus, and potassium, used singly and in combination. These elements were all applied in commercial form until

1911, after which the use of commercial nitrogen was discontinued and crop residues were substituted in its place. Nitrogen was supplied in the earlier years in 800 pounds of dried blood per acre. Phosphorus is applied in 200 pounds of steamed bone meal, and potassium in 100 pounds of potassium sulfate. At the beginning, 470 pounds of slaked lime was applied; but since 1912 limestone has been applied at the rate of 1,000 pounds per acre per year.

Table 9 presents, in summarized form, the results from the Antioch field. Because of an abnormality in Plot 1, the results from this plot are not considered. The data show that phosphorus is the one element standing out prominently as producing consistently beneficial results. Potassium applied in addition to phosphorus has, on the whole, not produced profitable results. Also, the

Table 9.—ANTIOCH FIELD: Yellow-Gray Silt Loam, Timber Soil; Late Wisconsin Glaciation

Average Annual Yields—Bushels or (tons) per acre
1902-1921

Serial plot No.	Soil treatment applied	Corn 8 crops	Oats 5 crops	Wheat 4 crops	Clover[1] 3 crops
1	0	23.9	32.3	15.8	1.33
2	L	21.3	26.8	13.2	1.26
3	LR	21.3	29.9	20.6	1.45
4	LP	30.7	43.6	36.7	1.61
5	LK	23.7	27.8	19.2	1.21
6	LRP	33.8	43.3	33.3	1.13
7	LRK	24.3	26.9	20.8	1.22
8	LPK	25.1	38.2	30.9	1.51
9	LRPK	38.3	42.6	28.0	1.00
10	RPK	38.4	44.7	30.2	1.28

[1] These figures represent the average combined yields of hay and seed, expressed as the equivalent of clover hay.

Lime applied and residues plowed under

Lime and phosphorus applied

Fig. 5.—Clover in 1913 on Antioch Field

results are unfavorable for the application of limestone. Limestone, however, is abundant in the subsoil of this type in the region of this field.

The Raleigh experiment field is located on the lower Illinoisan glaciation, in southern Illinois, in Saline county. This field is laid out into four series of ten plots each, under a rotation of wheat, corn, oats, and clover. The treatments, along with the summarized results, are given in Table 10.

The outstanding feature of these results is the effect of limestone. Altho manure alone produces a substantial increase, especially in the corn crop, when

Manure, limestone, phosphorous
Yield: 61 bushels per acre

Nothing applied
Yield: 15 bushels per acre

FIG. 6.—CORN ON RALEIGH FIELD IN 1920

TABLE 10.—RALEIGH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LOWER ILLINOISAN GLACIATION

Average Annual Yields—Bushels or (tons) per acre
1911-1921

Serial plot No.	Soil treatment applied	Corn 11 crops	Oats 11 crops	Wheat 7 crops	Legumes[1] 9 crops
1	0	15.8	10.2	6.2	(.42)
2	M	27.6	12.5	7.9	(.55)
3	ML	39.0	19.6	21.7	(1.14)
4	MLP	40.0	19.8	22.5	(1.36)
5	0	16.4	10.0	7.3	(.14)
6	R	19.4	12.8	8.8	(.19)
7	RL	34.3	21.2	19.7	(.71)
8	RLP	36.7	22.4	22.4	(.81)
9	RLPK	42.7	23.0	23.8	(.81)
10	0	20.2	11.2	6.9	(.30)

[1] These figures represent the average combined yields of clover and soybeans, whether hay or seed, expressed as the equivalnt of clover hay.

limestone is added a remarkable increase is found in all crops. A most important fact is that the organic matter can be effectively built up thru the use of crop residues, with the application of limestone, so that the crop yields are practically as high under this "grain system" of farming as where manure is used.

Phosphorus thus far has given only moderate returns in increased crop yields, but with an increasing quantity of organic matter and nitrogen it is probable that the phosphorus applications will show up more favorably on subsequent crops. As to the use of potassium, it is to be noted that aside from an increase of 6 bushels of corn in the residues system, the beneficial effect has not been sufficient to justify the use of this material.

In accounting for the discrepancy in the response to limestone on these two fields, the fact is to be considered that the Antioch field is located on the late Wisconsin glaciation, where the subsoil contains large quantities of limestone; while the Raleigh field represents the lower Illinoisan glaciation, the soil of which is very acid to a great depth.

In view of these variations, a general recommendation for a complete treatment for soil of this type, that will apply to all localities, cannot be given out until more information is acquired.

Fortunately, however, each farmer can determine for himself the need of limestone for his land by applying the simple tests for the presence of carbonates and soil acidity, as explained under the discussion of limestone on pages 28 and 29 of the Appendix.

Phosphorus, which has paid well on the Antioch field, and has given doubtful returns thus far at Raleigh, has varied considerably in its effect when used on other fields located on this same type of soil. In this situation, therefore, the present suggestion would be that each farmer might well try out phosphorus on his own land, on a limited scale, and be guided by the outcome of his experience. The low phosphorus content of the surface stratum of this soil is an indication that in a system of permanent agriculture the time is not far off when phosphorus will become a limiting element to crop production, and the wise farmer will watch carefully the indications and be ready to make timely provision for this need.

Deep Peat

As representing the deep peat type of soil, the results are introduced from an experiment field conducted at Manito in Mason county during the years 1902 to 1905 inclusive.

There were ten plots receiving the treatments indicated in Table 11.

The results of the four years' tests, as given in Table 11, are in complete harmony with the information furnished by the chemical composition of peat soil. Where potassium was applied, the yield was from three to four times as large as where nothing was applied. Where approximately equal money values of kainit and potassium chlorid were applied, slightly greater yields were obtained with the potassium chlorid, which, however, supplied about one-third more potassium than the kainit. On the other hand, either material furnished more potassium than was required by the crops produced.

TABLE 11.—MANITO FIELD: DEEP PEAT
Corn Yields—Bushels

Plot No.	Soil treatment for 1902	Corn 1902	Corn 1903	Soil treatment for 1904	Corn 1904	Corn 1905	Four crops
1	None	10.9	8.1	None	17.0	12.0	48.0
2	None	10.4	10.4	Limestone, 4000 lbs	12.0	10.1	42.9
3	Kainit, 600 lbs	30.4	32.4	Limestone, 4000 lbs. Kainit, 1200 lbs	49.6	47.3	159.7
4	Kainit, 600 lbs Acidulat'd bone, 350 lbs.	30.3	33.3	Kainit, 1200 lbs Steamed bone, 395 lbs.	53.5	47.6	164.7
5	Potassium chlorid, 200 lbs	31.2	33.9	Potassium chlorid 400 lbs	48.5	52.7	166.3
6	Sodium chlorid, 700 lbs	11.1	13.1	None	24.0	22.1	70.3
7	Sodium chlorid, 700 lbs	13.3	14.5	Kainit, 1200 lbs	44.5	47.3	......
8	Kainit, 600 lbs	36.8	37.7	Kainit, 600 lbs	44.0	46.0	164.5
9	Kainit, 300 lbs	26.4	25.1	Kainit, 300 lbs	41.5	32.9	125.9
10	None	14.9[1]	14.9	None	26.0	13.6	69.4

[1]Estimated from 1903; no yield was taken in 1902 because of a misunderstanding.

The use of 700 pounds of sodium chlorid (common salt) produced no appreciable increase over the best untreated plots, indicating that where potassium is itself actually deficient, salts of other elements cannot take its place.

Applications of 2 tons per acre of ground limestone produced no increase in the corn crops, either when applied alone or in combination with kainit, either the first year or the second.

Reducing the application of kainit from 600 to 300 pounds for each two-year period reduced the yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainit (Plot 9) furnished 60 pounds of potassium for the four years, an amount sufficient for 84 bushels of corn (grain and stalks). Attention is called to the fact that this is practically the difference between the yield of Plot 9 (125.9 bushels) and the yield obtained from Plot 2 (42.9 bushels), the poorest untreated plot.

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 24

ADAMS COUNTY SOILS

By J. G. MOSIER, F. W. WASCHER, W. R. LEIGHTY, and H. J. SNIDER

Prepared for Publication by L. H. SMITH

URBANA, ILLINOIS, AUGUST, 1922

IN RECOGNITION

The Soil Survey of Illinois was organized under the supervision of the late Dr. Cyril G. Hopkins. The work progressed for eighteen years under his guidance and the first eighteen soil reports bear his name as senior author. On October 6, 1919, Dr. Hopkins died in a foreign land in the service of the American Red Cross. It is the purpose to carry on to completion this great work of the Illinois Soil Survey in the spirit, and along the same general plan and lines of procedure, in which it was begun.

INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or land owner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and land owner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

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ADAMS COUNTY SOILS

APPENDIX

SUPPLEMENT

ADAMS COUNTY SOILS

By J. G. MOSIER, F. W. WASCHER, W. R. LEIGHTY, and H. J. SNIDER
Prepared for Publication by L. H. SMITH[1]

CLIMATE AND AGRICULTURAL PRODUCTION

Adams county is the most westerly county in Illinois. The south boundary is in a line with the geographical center of the state north and south; in other words, it is approximately 192 miles from the south line of Adams county to either end of the state. The county measures 30 miles north and south, and 32 miles east and west, embracing an area of about 850 square miles.

About one-fifth of the area of the county is bottom land, the major portion of which is included in the low lands of the Mississippi river. The upland in Adams county is occupied in larger part by timber soils and much of it is very rough and hilly. These hilly areas are interspersed by expanses of the more productive prairie soils.

The temperature of Adams county is characterized by a wide range between the extremes of summer and winter. The longest weather record in the county (which, however, covers but ten years) is at Quincy. The lowest temperature for this time was —20° in 1912 and 1918, while the highest was 108° in 1918, making for 1918 a range of 128 degrees, the greatest range for the ten years.

The average date of the last killing frost in spring is April 15; the earliest in fall, October 17. The growing season therefore is about 185 days long.

The average annual precipitation at Quincy from 1912 to 1921 was 33.78 inches. The average precipitation by months for this period was as follows: January, 1.65 inches; February, 1.31; March, 2.34; April, 3.46; May, 4.90; June, 4.92; July, 2.52; August, 3.25; September, 4.33; October, 2.16; November, 1.73; December, 1.28. The proportion of total rainfall occurring during each season was: winter, 12.5 percent; spring, 31.6 percent; summer, 31.6 percent; autumn, 24.3 percent. The year of heaviest rainfall in the ten years was 1915, when the precipitation was 48.17 inches; the driest year was 1912, when the rainfall was but 27.84 inches.

About 26 percent of the land in Adams county is better adapted to grazing than to the growing of ordinary tilled crops. In 1920, the census reported 3,844 farms, these farms having an average of 129.1 acres each, 97.1 acres of which were improved. Of these farms, 38.6 percent were operated by tenants, which was a decrease in tenantry of 5 percent in the last ten years.

The principal crops are corn, oats, wheat, rye, timothy, and clover. The Fourteenth Census of the United States (1920) reports the following as the acreage and yield of the more important crops. It must be remembered that these figures are for but a single year—that of 1919.

[1]J. G. Mosier, in charge of soil survey mapping; F. W. Wascher, in charge of field party; W. R. Leighty, in charge of soil analysis; H. J. Snider, in charge of experiment fields; L. H. Smith, in charge of publications.

Crops	*Acreage*	*Production*
Corn	94,498	3,594,497 bu.
Oats	45,498	1,403,422 "
Wheat	75,525	1,244,029 "
Rye	5,242	49,381 "
Soybeans	293	2,117 "
Timothy	11,286	12,615 tons
Timothy and clover mixed	19,246	21,257 "
Clover	7,882	7,822 "
Alfalfa	790	1,817 "
Silage crops	1,697	12,809 "
Corn for forage	9,844	18,807 "

The acreage of pasture is not given by the Census, but from other data it is found to be approximately 73,000.

The total value of the grains, hay, and seeds produced in 1919 was approximately 21⅓ million dollars.

The live-stock interests, including those of dairying, are of considerable importance, as shown by the following data taken from the Census of 1920.

Animals and animal products	*Number*	*Value*
Horses	17,741	$1,471,053
Mules	2,670	363,297
Beef cattle	23,947	1,341,454
Dairy cattle	15,853	983,385
Sheep	13,611	148,229
Swine	93,629	1,633,566
Poultry	90,329	381,791
Eggs and chickens	.....	1,040,876
Dairy products	.....	609,182
Wool	68,534 lbs.	37,567

Adams county is one of the great fruit-producing counties of the state, as shown by the following data:

Small fruit	
Strawberries	316,877 quarts
Raspberries	112,482 "
Blackberries and dewberries	20,969 "
Orchard fruit	
Apples	202,630 bushels
Peaches	1,712 "
Pears	13,734 "
Cherries	5,463 "
Grapes	140,626 pounds

SOIL FORMATION

The most important period in the geological history of the county, from the standpoint of soil formation, was the Glacial period, during which the material that later formed the soils was being deposited. At that time, snow and ice accumulated in the region of Labrador, west of Hudson Bay, and in the Rocky Mountains to such an amount that the mass pushed outward from these centers, especially southward, until a point was reached where the ice melted as rapidly as it advanced. As the ice advanced in these movements it buried everything, even the highest mountains, in its path. It would then recede slowly, and apparently normal conditions would be restored for a long period, after which another advance would occur. At least six of these great ice movements took place, each of which covered part of northern United States, altho the same parts were not covered every time.

LEGEND

000 Residual
200 Illinoisan Moraines
500 Upper Illinoisan Intermorainal Areas
800 Deep Loess Areas
1300 Old Bottom Land
1400 Late Swamp and Bottom Land
1500 Terraces

(a) UPLAND PRAIRIE SOILS

- 26 — Brown silt loam
- 28 — Brown-gray silt loam on tight clay
- 25.1 / 525.1 — Black silt loam on clay
- 71 / 871 — Brown fine sandy loam

(b) UPLAND TIMBER SOILS

- 34 — Yellow-gray silt loam
- 35 — Yellow silt loam
- 74 / 874 — Yellow-gray fine sandy loam
- 75 / 875 — Yellow fine sandy loam
- 65 — Yellow sandy loam

(c) 1500 TERRACE SOILS

- 526 — Brown silt loam
- 1560 — Brown sandy loam
- 528 — Brown-gray silt loam on tight clay
- 1534 — Yellow-gray silt loam
- 1536 — Yellow-gray silt loam over gravel
- 1564 — Yellow-gray sandy loam

(d) 1300 OLD BOTTOM-LAND SOILS

- 1328 — Brown-gray silt loam on tight clay
- 54 / 1354 — Mixed loam (small stream bottoms)

(e) 1400 LATE SWAMP AND BOTTOM-LAND SOILS

- 1426 — Brown silt loam
- 1460 — Brown sandy loam
- 15 / 1415 — Drab clay
- 2 / 1421 — Drab clay loam
- 1421.1 — Sandy drab clay loam
- 1454 — Mixed loam (Mississippi overflow)

(f) 000 RESIDUAL

- 099 — Rock outcrop
- Small areas rock outcrop

SOIL
UNIVERSITY O

URVEY MAP OF ADAMS COUNTY
LLINOIS AGRICULTURAL EXPERIMENT STATION

In advancing from the distant northern centers of accumulation, the ice gathered up all sorts and sizes of material, including clay, silt, sand, gravel, boulders, and even large masses of rock. Some of these materials were carried several hundred miles, and the coarser masses rubbed against the surface rocks or against each other until largely ground into rock powder, which now constitutes much of the soil. When, thru the melting of the ice, the limit of advance was reached, the material carried by the glacier was dropped, accumulating in a broad, undulating ridge or moraine, called a lateral moraine if formed at the side of the glacier, and a terminal moraine if formed at the end. If the ice melted more rapidly than the glacier advanced, the terminus of the glacier would recede, and the material would be deposited somewhat irregularly over the land, back of the moraines. Such a formation is known as a ground moraine. A glacier often would advance again, but not so far as before; or it would remain stationary, and another moraine would be built up. These moraines or ridges have a steep outward slope and a very gradual inward slope.

A pressure of forty pounds per square inch is exerted by a mass of ice one hundred feet thick, and these ice sheets may have been hundreds or even thousands of feet in thickness. The materials carried along in the ice, especially the boulders and pebbles, became powerful agents for grinding and wearing away the surface over which the ice passed. Preglacial ridges and hills were rubbed down, valleys were filled with the debris, and the surface features were changed entirely. The mixture of materials deposited by the glacier is known as boulder clay, till, glacial drift, or simply drift.

The material transported and deposited by a glacier varied with the character of the rocks over which it passed. Granites, limestones, sandstones, shales, etc., were encountered by the glacier, and both large and small masses of these were torn from their resting places by the enormous denuding power of the ice; they moved along with the glacier, were ground up more or less together, and were later deposited as the ice melted.

The names of the glaciers that had some part, either directly or indirectly, in the formation of the soils of Illinois are as follows: (1) The Nebraskan, which did not touch Illinois. (2) The Kansan, which covered parts of Hancock and Adams counties. The Yarmouth soil was developed from the surface of the Kansan glacial material. This soil was entirely covered by the next glacier. (3) The Illinoisan, which covered all of the state except the northwest corner (practically all of Jo Daviess county), the southern part of Calhoun county, and the seven southernmost counties. The Sangamon soil was formed from the surface of the Illinoisan drift. (4) The Iowan, which covered a part of northern Illinois. The area covered by this advance is difficult to determine because of the later glaciations. At about the close of the Iowan glacial advance, a wind deposit known as loess was laid down. The surface of this loess was formed into the Peorian soil, which was nearly all buried by the early Wisconsin glaciation. (5) The early Wisconsin glaciation, which covered the northeastern part of the state as far west as Peoria and south to Shelbyville. (6) The late Wisconsin glaciation, which extends to the west line of McHenry county and south to the town of Milford in Iroquois county.

THE GLACIATIONS OF ADAMS COUNTY

Only two of these glacial advances reached Adams county. The first was the Kansan, which came from the west or northwest, crossed the Mississippi river, and probably covered all except the southeast part of the county. A long period elapsed, the glacier melted, and a new soil was formed from the material deposited. Then another glacial advance occurred. This time the glacier (the Illinoisan) came from the northeast and covered the entire county, probably crossing the Mississippi river. It built up a moraine that extends diagonally across the county from southeast to northwest. This ridge, which was without doubt continuous at one time, has been divided by stream action into five short ridges which show very clearly the trend of the moraine. Another small ridge occurs about three miles east of the river at Quincy. Still another short moraine is found near Camp Point.

A later glacier, the Iowan, covered the northern part of the state, but did not reach Adams county. However, when it melted, large quantities of rock flour, or ground-up rock, were carried south and deposited on the flood plains of the rivers. From these flood plains the wind carried it on to the upland adjoining, making deposits varying in depth from 5 to 50 feet. This formation is called loess, and is made up largely of fine sand and still finer material (silt). The loess buried an old soil called the Sangamon soil.

The thickness of the glacial drift in Adams county varies from a few feet to 165 feet, but the average depth is not far from 65 feet. The deeper deposits represent an old pre-glacial valley which was filled with glacial drift or in which the drift was piled up in the form of a moraine. The deepest deposit found is near Coatsburg. Here a black soil two feet thick was encountered at a depth of 100 feet. This soil represents a period of normal conditions between glaciers, and is known as the Yarmouth soil, formed from Kansan drift.

The drift deposited by the Kansan glacier is in many places made up of a gray to yellow sand, while that left by the Illinoisan is a very heavy, compact clay with some gravel, usually of a blue color where the iron has not been oxidized. Very few boulders occur in the drift of either glacier.

Altho the county has been covered by glaciers, the glacial drift does not constitute any large part of the material from which the soils have been directly derived. A layer of wind-blown, or loessial, material that varies from four to twelve feet or more in thickness, constitutes the material from which the soil has been formed. The coarser material was deposited within four or five miles from the edge of the bottom land, giving the soil in those localities a fine sandy appearance. Often where much erosion has occurred, the loess has been all removed, in which case the soil may be formed from glacial drift, but this occurs only in small patches.

PHYSIOGRAPHY AND DRAINAGE

Adams county has extremes in topography. The northeast part of the county has large areas of extremely flat, and originally poorly drained land. The west and south parts have extensive areas of hilly, almost untillable land mixed with areas of undulating, tillable land.

The present topography is largely the result of erosion, glacial deposition being of secondary influence. Two distinct drainage basins occur in the

LEGEND

- 000 Residual
- 200 Illinoisan Moraines
- 500 Upper Illinoisan Intermorainal Areas
- 800 Deep Loess Areas
- 1300 Old Bottom Land
- 1400 Late Swamp and Bottom Land
- 1500 Terraces

(a) UPLAND PRAIRIE SOILS

- 26 Brown silt loam
- 28 Brown-gray silt loam on tight clay
- 25.1 / 525.1 Black silt loam on clay
- 71 / 871 Brown fine sandy loam

(b) UPLAND TIMBER SOILS

- 34 Yellow-gray silt loam
- 35 Yellow silt loam
- 74 / 874 Yellow-gray fine sandy loam
- 75 / 875 Yellow fine sandy loam
- 65 Yellow sandy loam

(c) 1500 TERRACE SOILS

- 1526 Brown silt loam
- 1560 Brown sandy loam
- 1528 Brown-gray silt loam on tight clay
- 1534 Yellow-gray silt loam
- 1536 Yellow-gray silt loam over gravel
- 1564 Yellow-gray sandy loam

(d) 1300 OLD BOTTOM-LAND SOILS

- 1328 Brown-gray silt loam on tight clay
- 54 / 1354 Mixed loam (small stream bottoms)

(e) 1400 LATE SWAMP AND BOTTOM-LAND SOILS

- 1426 Brown silt loam
- 1460 Brown sandy loam
- 15 / 1415 Drab clay
- 21 / 1421 Drab clay loam
- 1421 Sandy drab clay loam
- 1454 Mixed loam (Mississippi overflow)

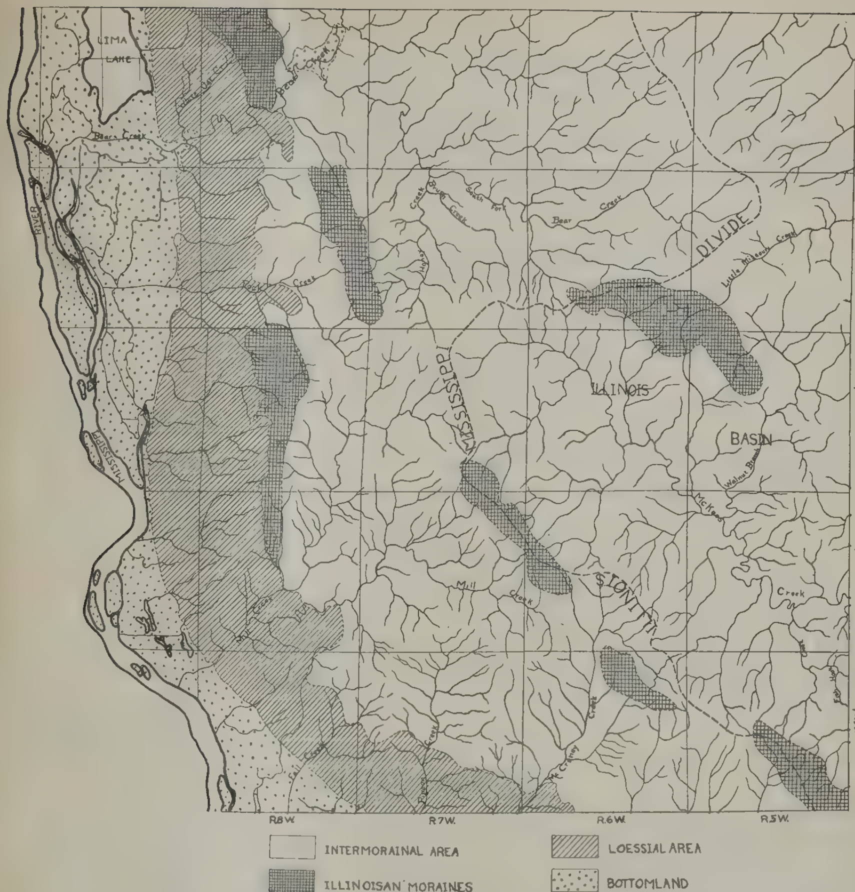
(f) 000 RESIDUAL

- 099 Rock outcrop
- Small areas rock outcrop

Scale
0 ¼ ½ 1 2 Miles

SOIL
UNIVERSITY O

URVEY MAP OF ADAMS COUNTY
LLINOIS AGRICULTURAL EXPERIMENT STATION



MAP SHOWING THE DRAINAGE BASINS OF ADAMS COUNTY WITH MORAINAL, INTERMORAINAL, LOESSIAL, AND BOTTOM-LAND AREAS

county—those of the Mississippi and the Illinois rivers. The Mississippi basin is drained by Pigeon, Mill, and Bear creeks, the Illinois basin by McKees creek, and the northeast part of the county by tributaries of Crooked creek.

Following are the altitudes of some places in Adams county: Adams, 700 feet; Beverly, 856; Blacks, 728; Burton, 620; Camp Point, 740; Chattan, 715; Chestline, 740; Clayton, 744; Coatsburg, 769; Columbus, 732; Ewbanks, 733; Fair Weather, 839; Fall Creek, 451; Fowler, 733; Golden, 717; Kellerville, 730; La Prairie, 707; Lima, 620; Loraine, 644; Marblehead, 458; Mendon, 654; Paloma, 743; Payson, 726; Quincy, 488; Richfield, 735; Ursa, 588; Woodville, 664.

The highest point in the county is on the moraine in Section 34, southeast of Beverly, where the altitude is 858 feet. The Camp Point-Coatsburg ridge is 750 to 780 feet high; the ridge at Fowler, 700 to 750 feet. Low water in the Mississippi river at Quincy is 458 feet.

SOIL TYPES

About one-fifth of Adams county is bottom land and four-fifths upland. The soils, according to the survey, are divided into the following groups:

(a) Upland Prairie Soils, including the upland soils that have not been covered with forests—at least for any great length of time—and on which the luxuriant growth of prairie grasses has produced relatively large amounts of organic matter.

TABLE 1.—SOIL TYPES OF ADAMS COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (200, 500, 800)			
226, 526	Brown silt loam	102.71	65,734	12.11
228, 528	Brown-gray silt loam on tight clay	24.18	15,475	2.85
525.1	Black silt loam on clay	15.07	9,645	1.78
871	Brown fine sandy loam	20.89	13,370	2.46
		162.85	104,224	19.20
	(b) Upland Timber Soils (200, 500, 800)			
234, 534	Yellow-gray silt loam	232.19	148,602	27.38
235, 535	Yellow silt loam	181.13	115,923	21.36
874	Yellow-gray fine sandy loam	56.18	35,955	6.63
875	Yellow fine sandy loam	30.78	19,699	3.63
265, 565	Yellow sandy loam	8.37	5,357	.99
		508.65	325,536	59.99
	(c) Terrace Soils (1500)			
1526	Brown silt loam	.18	115	.02
1560	Brown sandy loam	.77	493	.09
1528	Brown-gray silt loam on tight clay	.20	128	.02
1534	Yellow-gray silt loam	2.18	1,395	.26
1536	Yellow-gray silt loam over gravel	.62	397	.07
1564	Yellow-gray sandy loam	.10	64	.01
		4.05	2,592	.47
	(d) Old Bottom-Land Soils (1300)			
1328	Brown-gray silt loam on tight clay	4.95	3,168	.58
1354	Mixed loam (small stream bottoms)	60.88	38,963	7.18
		65.83	42,131	7.76
	(e) Late Swamp and Bottom-Land Soils (1400)			
1426	Brown silt loam	33.95	21,728	4.00
1460	Brown sandy loam	6.54	4,186	.77
1415	Drab clay	8.68	5,555	1.02
1421	Drab clay loam	15.96	10,215	1.88
1421.1	Sandy drab clay loam	.30	192	.04
1454	Mixed loam (Mississippi overflow)	17.40	11,136	2.05
		82.83	53,012	9.76
	(f) Residual Soils (000)			
099	Rock outcrop	.41	262	.05
	Water	23.53	15,059	2.77
	Total	848.15	542,816	100.00

LEGEND

- 000 Residual
- 200 Illinoisan Moraines
- 500 Upper Illinoisan Intermorainal Areas
- 800 Deep Loess Areas
- 1300 Old Bottom Land
- 1400 Late Swamp and Bottom Land
- 1500 Terraces

(a) UPLAND PRAIRIE SOILS

- 26 Brown silt loam
- 28 Brown-gray silt loam on tight clay
- 25.1 / 525.1 Black silt loam on clay
- 71 / 871 Brown fine sandy loam

(b) UPLAND TIMBER SOILS

- 34 Yellow-gray silt loam
- 35 Yellow silt loam
- 74 / 874 Yellow-gray fine sandy loam
- 75 / 875 Yellow fine sandy loam
- 65 Yellow sandy loam

(c) 1500 TERRACE SOILS

- 1526 Brown silt loam
- 1560 Brown sandy loam
- 1528 Brown-gray silt loam on tight clay
- 1534 Yellow-gray silt loam
- 1536 Yellow-gray silt loam over gravel
- 1564 Yellow-gray sandy loam

(d) 1300 OLD BOTTOM-LAND SOILS

- 1328 Brown-gray silt loam on tight clay
- 54 / 1354 Mixed loam (small stream bottoms)

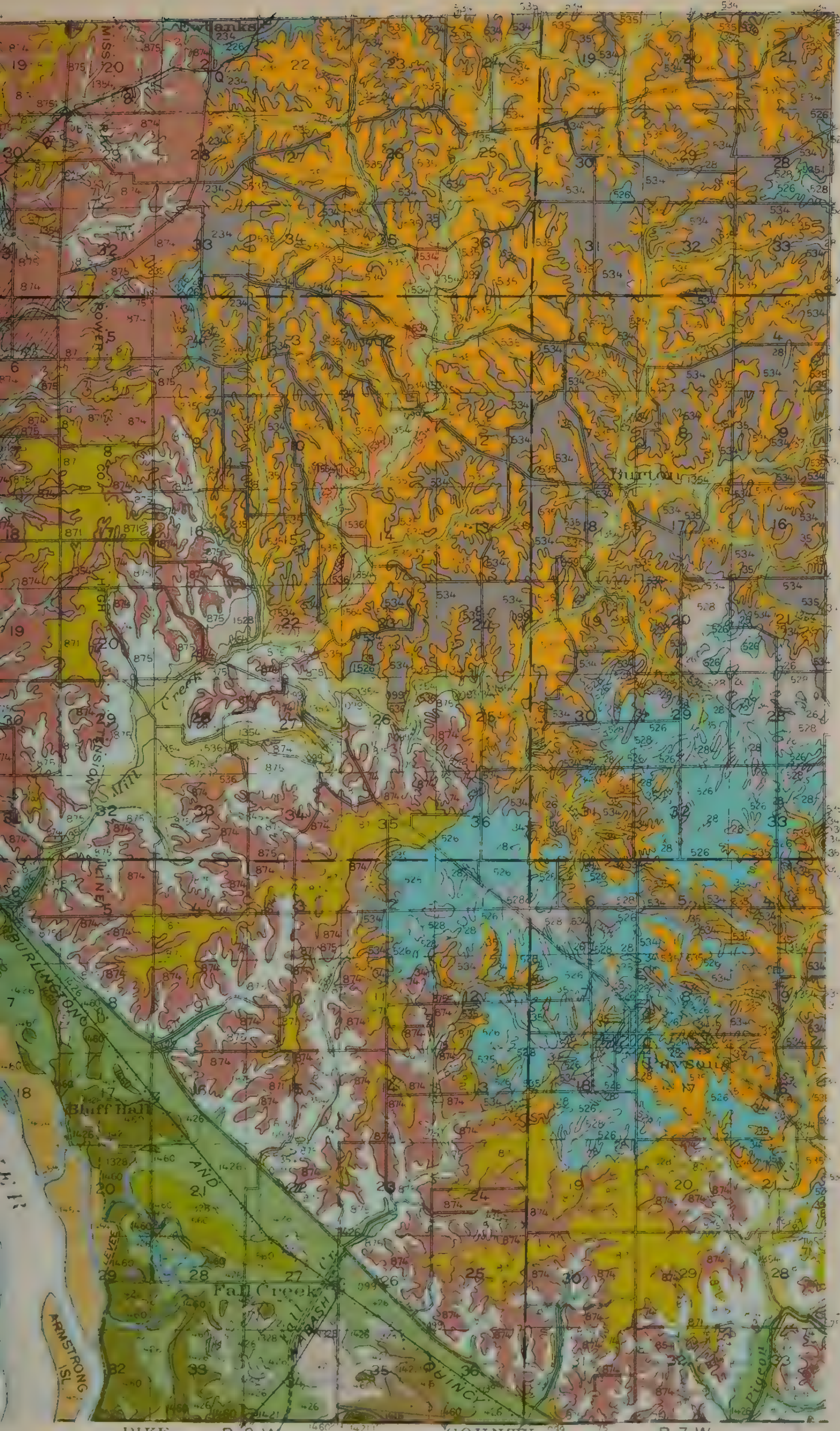
(e) 1400 LATE SWAMP AND BOTTOM-LAND SOILS

- 1426 Brown silt loam
- 1460 Brown sandy loam
- 15 / 1415 Drab clay
- 2 / 1402 Drab clay loam
- 1421 Sandy drab clay loam
- 1454 Mixed loam (Mississippi overflow)

(f) 000 RESIDUAL

- 099 Rock outcrop
- Small areas rock outcrop

SOIL
UNIVERSITY O



RVEY MAP OF ADAMS COUNTY

LLINOIS AGRICULTURAL EXPERIMENT STATION

(b) Upland Timber Soils, including nearly all the upland areas that are now, or were formerly, covered with forests.

(c) Terrace Soils, including bench lands, or second bottom lands, formed by deposits from overloaded streams; and gravel outwash plains, formed by broad sheets of water arising from the melting of the glaciers.

(d) Old Bottom-Land Soils, including the low-lying land along streams other than the Mississippi river and formed of older materials than those of the late bottom lands.

(e) Late Swamp and Bottom-Land Soils, including the bottom lands of the Mississippi river and representing a newer formation than the old bottom lands.

(f) Residual, including rock-outcrop areas.

Table 1 gives a list of the types of soil found in Adams county, the area of each type in square miles and in acres, and also its percentage of the total area. The accompanying map shows the location and boundaries of each type of soil, even down to areas of a few acres.

For explanations concerning the classification of soils and the interpretation of the map and tables, the reader is referred to the first part of the Appendix.

INVOICE OF PLANT FOOD IN ADAMS COUNTY SOILS

SOIL ANALYSIS

The composition reported in the accompanying tables is, for the more extensive types, the average of several analyses. These analyses show that soils, like most things in nature, are variable; but for general purposes the average may be considered sufficient to characterize the soil type.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed, but it should be understood that the rate of liberation, as explained in the Appendix (page 34), is governed by many factors.

For convenience in making practical application of the chemical analyses the results have been translated from the percentage basis and are presented here in terms of pounds per acre. In this, the assumption is made that for ordinary types, a stratum of dry soil 6⅔ inches thick weighs 2,000,000 pounds. It is recognized that this value is only an approximation, but it is believed that it will suffice for the purposes intended. It is, of course, a simple matter to convert these figures back to the percentage basis in case one desires for any purpose to consider the information in that form.

THE SURFACE SOIL

In Table 2 are reported the amount of organic carbon (which serves as a measure of the organic matter), and the total quantities of nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium contained in 2 million pounds of the surface soil (the plowed soil of an acre about 6⅔ inches deep) of each type in Adams county.

TABLE 2.—PLANT FOOD IN THE SOILS OF ADAMS COUNTY, ILLINOIS: SURFACE SOIL
Average pounds per acre in 2 million pounds of surface soil (about 0-6⅔ inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (200, 500, 800)							
226 526	Brown silt loam	47 090	3 630	1 000	720	32 490	5 270	8 860
228 528	Brown-gray silt loam on tight clay	35 720	3 170	860	710	31 700	3 450	6 930
525.1	Black silt loam on clay	44 220	3 660	990	800	31 270	5 560	9 310
871	Brown fine sandy loam	36 610	3 080	1 020	530	35 090	6 520	9 580
	(b) Upland Timber Soils (200, 500, 800)							
234 534	Yellow-gray silt loam	23 930	2 220	720	470	32 890	5 160	8 420
235 535	Yellow silt loam	20 730	1 900	620	430	29 730	4 790	4 550
874	Yellow-gray fine sandy loam	25 700	2 380	850	530	33 720	5 390	9 550
875	Yellow fine sandy loam	15 920	1 500	600	340	29 600	6 600	7 800
265 565	Yellow sandy loam	17 860	1 600	460	600	15 460	2 640	3 980
	(c) Terrace Soils (1500)							
1526	Brown silt loam	38 920	3 360	1 040	500	32 160	5 080	10 740
1560	Brown sandy loam	10 160	1 120	920	320	23 860	4 720	8 700
1528	Brown-gray silt loam on tight clay	16 780	1 960	800	500	29 120	5 020	9 300
1534	Yellow-gray silt loam	19 140	1 760	820	480	26 340	2 500	5 560
1536	Yellow-gray silt loam over gravel	18 140	2 140	860	440	33 580	5 060	9 900
1564	Yellow-gray sandy loam	12 900	1 520	620	460	22 400	3 280	7 640
	(d) Old Bottom-Land Soils (1300)							
1328	Brown-gray silt loam on tight clay	35 960	3 480	1 220	760	28 380	6 700	10 880
1354	Mixed loam	25 850	2 530	960	560	30 840	6 650	10 550
	(e) Late Swamp and Bottom-Land Soils (1400)							
1426	Brown silt loam	26 890	2 230	1 050	550	32 980	3 990	9 550
1460	Brown sandy loam	9 980	1 260	920	360	24 980	4 140	7 340
1415	Drab clay	36 410	3 240	1 320	710	32 170	8 630	10 700
1421	Drab clay loam	39 020	3 760	1 840	640	34 700	5 660	10 820
1421.1	Sandy drab clay loam	53 740	5 060	1 040	1 060	29 720	8 900	12 240
1454	Mixed loam	23 860	2 660	1 120	680	31 340	8 980	10 440

LIMESTONE AND SOIL ACIDITY.—In connection with these tabulated data it should be explained that the figures on limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm, and even from field to field. Therefore no attempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, pages 36 and 37.

Because of the extreme variations frequently found within a given soil type with respect to the presence of limestone and acidity, no attempt is made to include in the tabulated results figures purporting to represent the average amounts of these substances present in the respective types. Such averages cannot give the farmer the specific information he needs regarding the lime requirements of a given field. Fortunately, however, very simple tests which

LEGEND

000 Residual
200 Illinoisan Moraines
500 Upper Illinoisan Intermorainal Areas
800 Deep Loess Areas
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(a) UPLAND PRAIRIE SOILS

26 Brown silt loam
28 Brown-gray silt loam on tight clay
25.1 525.1 Black silt loam on clay
71 871 Brown fine sandy loam

(b) UPLAND TIMBER SOILS

34 Yellow-gray silt loam
35 Yellow silt loam
74 874 Yellow-gray fine sandy loam
75 875 Yellow fine sandy loam
65 Yellow sandy loam

(c) 1500 TERRACE SOILS

1526 Brown silt loam
1560 Brown sandy loam
1528 Brown-gray silt loam on tight clay
1534 Yellow-gray silt loam
1536 Yellow-gray silt loam over gravel
1564 Yellow-gray sandy loam

(d) 1300 OLD BOTTOM-LAND SOILS

1328 Brown-gray silt loam on tight clay
54 1354 Mixed loam (small stream bottoms)

(e) 1400 LATE SWAMP AND BOTTOM-LAND SOILS

1426 Brown silt loam
1460 Brown sandy loam
15 1415 Drab clay
21 1421 Drab clay loam
1421 Sandy drab clay loam
1454 Mixed loam (Mississippi overflow)

(f) 000 RESIDUAL

099 Rock outcrop
Small areas rock outcrop

Scale
0 ¼ ½ 1 2 Miles

SOIL
UNIVERSITY OF

RVEY MAP OF ADAMS COUNTY
LLINOIS AGRICULTURAL EXPERIMENT STATION

TABLE 3.—PLANT FOOD IN THE SOILS OF ADAMS COUNTY, ILLINOIS: SUBSURFACE SOIL

Average pounds per acre in 4 million pounds of subsurface soil (about 6⅔-20 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (200, 500, 800)							
226, 526	Brown silt loam	67 390	5 230	1 740	1 090	66 530	13 400	16 450
228, 528	Brown-gray silt loam on tight clay	42 460	3 480	1 360	920	64 380	12 780	15 800
525.1	Black silt loam on clay	57 980	4 740	1 400	1 200	63 120	12 380	18 600
871	Brown fine sandy loam	67 700	5 300	1 960	1 020	71 620	14 280	19 100
	(b) Upland Timber Soils (200, 500, 800)							
234, 534	Yellow-gray silt loam	23 210	2 610	1 350	640	67 150	16 220	15 400
235, 535	Yellow silt loam	14 520	1 770	1 000	600	54 270	12 480	6 630
874	Yellow-gray fine sandy loam	38 620	3 600	1 500	820	69 820	14 440	17 860
875	Yellow fine sandy loam	15 800	1 560	1 280	640	50 160	20 560	14 240
265, 565	Yellow sandy loam	21 680	1 960	880	960	30 320	6 520	6 720
	(c) Terrace Soils (1500)							
1526	Brown silt loam	49 280	4 160	1 680	1 120	65 600	14 000	20 920
1560	Brown sandy loam	22 360	2 680	1 920	800	47 880	9 760	18 680
1528	Brown-gray silt loam on tight clay	26 400	3 280	1 600	840	59 360	9 360	19 040
1534	Yellow-gray silt loam	22 720	2 320	1 720	680	56 040	8 040	16 080
1536	Yellow-gray silt loam over gravel	15 520	2 640	1 640	640	71 120	13 120	17 600
1564	Yellow-gray sandy loam	16 560	1 840	1 120	560	46 640	7 720	14 360
	(d) Old Bottom-Land Soils (1300)							
1328	Brown-gray silt loam on tight clay	36 200	3 800	1 640	1 000	57 160	12 480	17 560
1354	Mixed loam	40 840	4 230	1 840	960	61 320	13 350	20 690
	(e) Late Swamp and Bottom-Land Soils (1400)							
1426	Brown silt loam	45 330	3 410	2 000	890	65 880	7 770	18 670
1460	Brown sandy loam	17 480	2 240	1 840	920	49 520	8 400	15 440
1415	Drab clay	42 540	4 240	2 000	840	63 140	15 300	19 680
1421	Drab clay loam	49 280	4 720	2 800	960	67 080	13 800	18 640
1421.1	Sandy drab clay loam	47 320	4 760	1 360	1 080	57 640	16 800	27 680
1454	Mixed loam	33 480	3 000	1 480	800	57 280	15 720	19 320

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

can be made at home will furnish this important information, and these tests are described on pages 36 and 37 of the Appendix.

Altho the variation among the different types of soil of Adams county with respect to the quantity of the plant food elements is not so extreme as is found in many other counties, nevertheless there are wide fluctuations, as a comparison of the figures in Table 2 will show. For example, it may be noted that one type of soil contains 4½ times the quantity of nitrogen as another (compare drab clay loam of the bottom lands with brown sandy loam of the terrace soils). The supply of phosphorus in the surface stratum of the different types varies, as it happens, in practically the same degree, the range being from 1,840 pounds per acre in the drab clay loam to 460 pounds in yellow sandy loam. A sulfur content of 340 pounds per acre is found in the yellow fine sandy loam, while

TABLE 4.—PLANT FOOD IN THE SOILS OF ADAMS COUNTY, ILLINOIS: SUBSOIL
Average pounds per acre in 6 million pounds of subsoil (about 20-40 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (200, 500, 800)							
226, 526	Brown silt loam............	33 330	3 750	2 400	990	96 000	30 530	29 700
228, 528	Brown-gray silt loam on tight clay................	29 550	3 870	2 220	1 290	91 470	33 330	26 430
525.1	Black silt loam on clay......	38 940	3 600	2 040	930	89 010	37 260	29 850
871	Brown fine sandy loam......	42 990	4 320	2 700	1 080	105 810	30 420	29 670
	(b) Upland Timber Soils (200, 500, 800)							
234, 534	Yellow-gray silt loam.......	20 990	2 760	2 750	690	98 640	35 380	27 850
235, 535	Yellow silt loam............	14 800	2 220	1 360	1 320	75 240	20 320	9 060
874	Yellow-gray fine sandy loam.	22 080	2 880	3 060	1 140	98 580	31 470	29 040
875	Yellow fine sandy loam......	19 200	1 860	1 260	600	64 560	33 120	24 240
265, 565	Yellow sandy loam.........	24 000	2 940	1 080	900	55 140	14 880	9 780
	(c) Terrace Soils (1500)							
1526	Brown silt loam............	38 520	3 540	2 520	1 080	93 240	36 180	37 560
1560	Brown sandy loam..........	16 380	2 280	2 580	780	70 320	13 800	27 360
1528	Brown-gray silt loam on tight clay................	28 260	3 780	2 640	1 080	97 500	18 120	26 700
1534	Yellow-gray silt loam.......	17 760	2 280	2 880	780	82 440	23 520	25 440
1536	Yellow-gray silt loam over gravel..................	11 940	3 180	3 960	900	107 160	28 740	26 220
1564	Yellow-gray sandy loam.....	15 600	1 980	1 800	600	70 440	15 780	22 320
	(d) Old Bottom-Land Soils (1300)							
1328	Brown-gray silt loam on tight clay................	12 720	2 640	1 800	780	85 440	21 840	29 940
1354	Mixed loam................	30 920	3 500	1 880	1 300	83 640	18 420	27 020
	(e) Late Swamp and Bottom Land-Soils (1400)							
1426	Brown silt loam............	68 150	5 540	3 320	1 240	96 100	13 200	27 660
1460	Brown sandy loam..........	17 820	2 280	2 640	1 020	70 440	12 120	21 360
1415	Drab clay..................	36 720	4 050	2 250	1 020	86 370	24 630	41 610
1421	Drab clay loam............	19 860	3 660	3 240	1 140	97 020	13 080	30 480
1421.1	Sandy drab clay loam.......	29 640	3 660	3 240	1 140	90 120	23 160	36 720
1454	Mixed loam................	23 220	2 880	1 980	900	83 940	22 920	27 900

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

in the sandy drab clay loam there are 1,060 pounds of this element. The magnesium varies in the different types from 2,500 to 8,980 pounds, and the calcium content ranges from 620 to 12,240.

It is important to note that some of the plant-food elements are present in very limited quantities as compared with crop requirements. Some simple computations are of interest in this connection. Assume, for example, that a four-field crop rotation of wheat, corn, oats, and clover yields 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. These are high yields, but not impossible, for they are sometimes obtained. It will be found that the most prevalent soil of Adams county, the yellow-gray silt loam, contains only enough total nitrogen in the plowed soil for the production of such yields to supply about four rotations.

With respect to phosphorus, the condition differs only in degree, this soil containing no more of that essential element than would be required for about ten crop rotations yielding at the rates suggested above. On the other hand, the amount of potassium in the surface layer of this common soil type is sufficient for more than 25 centuries if only the grain is sold, or for nearly 400 years if the total crops should be removed from the land and nothing returned.

These general statements relating to the total quantities of these plant-food materials in the plowed soil of the most prevalent type in the county certainly emphasize the fact that the supplies of some of these necessary elements of fertility are extremely limited when measured by the needs of large crop yields for even one or two generations of people.

THE SUBSURFACE AND SUBSOIL

In Tables 3 and 4 are recorded the amounts of plant food in the subsurface and the subsoil of the different types. It should be remembered, however, that these supplies are of little value unless the top soil is kept rich. These tables also show great stores of potassium in the prevailing types of soil but only limited amounts of nitrogen and phosphorus, in agreement with the data for the corresponding surface samples.

DESCRIPTION OF INDIVIDUAL SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of Adams county cover an area of 162.85 square miles, or about one-fifth of the entire area of the county. They usually occupy the less eroded areas of the upland. They are black or dark brown in color, owing to their high organic-matter content. This land in its virgin condition was covered with prairie grasses, the partially decayed roots of which have been the principal source of the organic matter. The flat, poorly drained areas contain the greater amounts of organic matter, owing to the more luxuriant growth of the grasses there and to the excessive soil moisture which provided conditions better adapted for the preservation of their roots.

Brown Silt Loam (226, 526)

Brown silt loam is the third most extensive type in Adams county. It covers an area of 102.71 square miles, or 12.11 percent of the area of the county. It is widely distributed over the county, but the greatest area occurs in the four northeast townships.

This type occupies the slightly undulating to almost flat upland, some of which may at one time have been overspread for a short period by timber but not sufficiently long to have produced any marked change in the character of the soil. These forests consisted largely of black walnut, wild cherry, hackberry, ash, hard maple, and elm. A black walnut soil is recognized generally by farmers as being one of the best timber soils because of the fact that it still contains a large amount of organic matter, characteristic of prairie soils. After the growth of several generations of trees, the organic matter generally becomes so reduced that such a

soil would be classed as a timber type instead of a prairie type. In the southern and western parts of the county, the brown silt loam is confined to the divides that have not been dissected to any extent by the erosion of streams. The surface drainage is usually good, altho in a few cases in the northeastern part, artificial drainage is very desirable. The soil was formed from wind-blown loessial material which covers the county to a variable depth, usually more than three feet.

The surface soil, 0 to 6⅔ inches, is a brown silt loam varying on the one hand to black as it grades into black silt loam on clay (525.1), and on the other hand to brownish gray or grayish yellow as it grades into either brown-gray silt loam on tight clay (528) or yellow-gray silt loam (534). It contains a sufficient amount of the coarser constituents (coarse silt and fine sand) to make it work easily, and yet enough fine silt and clay to give it stability and cause it to granulate under proper conditions. It contains from 60 to 70 percent of silt, 10 to 15 percent of clay, and from 15 to 40 percent of sand, mostly fine. The organic-matter content varies from 3.5 to 4.5 percent, with an average of approximately 4.1 percent, or 41 tons per acre. There is less organic matter in the more rolling areas, and in places where the type grades into the timber soil. In the poorly drained parts, the larger moisture content encouraged a ranker growth of grasses and at the same time furnished more favorable conditions for the preservation of their roots.

The natural subsurface stratum is a silt loam varying in thickness from 6 to 12 inches and in color from a dark brown to a yellowish brown. Both color and depth vary with the topography, the type being lighter in color and shallower on the more rolling areas. The same effect is produced where the type grades into the timber soil. The subsurface as sampled (6⅔ to 20 inches) contains about 2.9 percent of organic matter, or 58 tons per acre.

The natural subsoil begins at a depth of 12 to 18 inches beneath the surface. It is a yellowish, drabbish, or grayish clayey silt or silty clay. It is somewhat plastic when wet, and has a tendency to be somewhat compact and more impervious than in most other areas of the state where the type occurs. Because of this condition, drainage does not take place so readily as in the type generally.

Management.—When the virgin brown silt loam was first cropped, the soil was in fine tilth, worked easily, and large crops could be grown with much less work than now. Continuous cropping, however, to corn or corn and oats with the burning of corn stalks, stubble, grass, and in many cases even straw, has destroyed the tilth in a great measure and now the soil is more difficult to work, washes badly, runs together, and bakes more readily. Unless the moisture conditions are very favorable, the ground plows up cloddy and unless well-distributed rains follow, a good seed bed is difficult to produce. The clods may remain all season. Much plant food is locked up in them and thus made unavailable, so that the best results cannot be obtained. This condition of poor tilth may become serious if the present methods of management continue; it is already one of the factors that limits crop yields. The remedy is to increase the organic-matter content by plowing under every available form of vegetable

material, such as farm manure, corn stalks, straw, clover, stubble, and even weeds.

The deficiency of organic matter in the soil is shown by the way the fall-plowed land runs together during the winter. Much more work is required to produce a seed bed than was formerly the case. The result is that corn is frequently planted in poorly prepared seed beds and as a consequence it "fires" badly. In the spring, fall-plowed land should be disked early and deeply for the purpose of conserving moisture, raising the temperature, and making plant food available.

The addition of fresh organic matter is not only of great value in improving the physical condition of this type of soil, but it is of even greater importance because of its nitrogen content and because of its power, as it decays, to liberate potassium from the inexhaustible supply in the minerals of the soil, and phosphorus from the phosphate contained in or applied to the soil.

For permanent, profitable systems of farming on brown silt loam, phosphorus should be applied liberally; and sufficient organic matter should be provided to furnish the necessary amount of nitrogen. On much of the type, limestone is already deficient. An application of 2 tons of limestone, and ½ ton of finely ground rock phosphate per acre every four years, with the return to the soil of all manure made from a rotation, will maintain the fertility of this type; altho heavier applications of phosphate may well be made during the first two or three rotations, and the first application of limestone may well be 4 tons per acre. If grain farming is practiced, the rotation may be wheat, corn, oats, and clover, with an extra seeding of clover (preferably sweet clover) as a cover crop in the wheat, to be plowed under late in the fall or in the following spring for corn; and most of the crop residues, including the clover chaff from the seed crops, should also be plowed under. In live-stock farming, the regular rotation may be extended to five or six years by seeding both timothy and clover with the oats, and pasturing one or two years. Alsike may well replace red clover at times, in order to avoid clover sickness. In either the grain or the live-stock system, alfalfa may be grown on a fifth field and moved every five years, the hay being fed or sold. Sweet clover is especially valuable on this type of soil because of its deep rooting habit and the effect that this has upon underdrainage.

For other suggestions regarding crop rotation systems, see page 42 of the Appendix. For results secured in field experiments on brown silt loam, see page 45 of the Supplement. On page 53 will be found a description of the experiment field located at Clayton in Adams county along with the results obtained.

Brown-Gray Silt Loam on Tight Clay (228, 528)

Brown-gray silt loam on tight clay is somewhat closely associated with brown silt loam and is widely distributed thruout the county. In topography it is usually flat—so much so that surface drainage is rather difficult. It covers an area of 24.18 square miles, or 2.85 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a brown to grayish brown silt loam containing a perceptible amount of fine sand. This is quite evident after a

heavy rain, when the fine sand is washed out on to the surface. The organic-matter content is approximately 3.1 percent, or 31 tons per acre. As a general rule, this stratum does not contain quite so much clay as the average brown silt loam (526), and for this reason it is somewhat more pulverulent.

The natural subsurface is a silt loam varying in thickness from 6 to 12 inches and in color from brown to light gray. It is very low in organic matter. As a rule, the top two or three inches of the subsurface is a brown silt loam, while the lower portion of this stratum is gray. A considerable amount of coarse silt and fine sand is present. When dry, the stratum is decidedly gray. It is rather impervious to the downward movement of water, and so acts to some extent in preventing drainage. The subsurface as sampled (6⅔ to 20 inches) contains about 1.7 percent of organic matter, or 34 tons per acre.

The natural subsoil begins at a depth of 12 to 18 inches beneath the surface of the ground. It consists of a yellowish or brownish, compact, plastic, impervious clay, which renders drainage extremely difficult. As a rule, this impervious clay ends at 34 to 40 inches, and is followed by a yellow or grayish material much coarser in composition, quite friable, and not very plastic.

Management.—Much that was said in regard to the management of brown silt loam applies also to this type, especially in regard to organic matter. Methods should be undertaken for its permanent improvement. Frequently a farmer, instead of making improvement of a run-down soil, attempts to find a crop that will grow on it without improvement. As a result crops such as timothy are grown; and in some places, altho not in Adams county, redtop has been the crop of last resort. This is poor practice, since it only means a still further depletion of plant food.

After drainage, the first requirement in the improvement of this soil is limestone. Two to three tons per acre should be applied; this will put the soil in condition for the growing of legumes. The importance of legumes on this type of soil cannot be over-emphasized. They add nitrogen to the soil, and at the same time furnish a very valuable form of organic matter. The deep-rooting legumes open up the subsoil and allow better drainage; for this purpose sweet clover is especially desirable. All available organic matter, in any form, should be turned back into the soil. A half-ton of rock phosphate each rotation is very desirable as a means of building up the phosphorus content in which the type is deficient.

Black Silt Loam on Clay (525.1)

Black silt loam on clay is found almost exclusively in the northeastern four townships of the county, occurring on the flat and poorly drained areas. The type covers 15.07 square miles, or 1.78 percent of the total area of the county.

The surface soil, 0 to 6⅔ inches, varies from a black silt loam to a black clayey silt loam, some small areas even passing into a black clay loam. The surface stratum contains about 3.8 percent of organic matter, or 38 tons per acre.

The natural subsurface extends to a depth of 17 to 20 inches, and is usually heavier than the surface soil. It is black in color, becoming lighter with increas-

ing depth. This stratum as sampled (6⅔ to 20 inches) contains about 2.5 percent of organic matter, or 50 tons per acre.

The subsoil varies from a black to a pale yellow clay, very heavy and somewhat impervious.

Management.—Altho this type is fairly well supplied at present with organic matter and nitrogen, it is very desirable that these materials be maintained or even increased. This is especially true of the organic matter, which is necessary in order to keep the soil in good physical condition and maintain desirable working conditions. Crop residues, farm manure, and legumes should be turned under. The soil is becoming acid, and it will therefore be necessary, in order to provide for the best growth of legumes, to apply about 2 tons of limestone per acre. A very desirable form of legume for this type is sweet clover, as its deep-rooting habit opens up the subsoil and thus promotes better drainage.

This type is fairly well supplied with phosphorus, yet it would be desirable to begin to increase the content of this element by applying a half ton of finely ground rock phosphate per acre about once every four or five years.

Drainage is very necessary. As a rule, farmers have the impression that this type will not tile-drain. It is true that it will not drain so well as brown silt loam (526) and many other types, but by keeping it well supplied with limestone and growing deep-rooting legumes, there is no question but that it may be tile-drained satisfactorily.

Brown Fine Sandy Loam (871)

Brown fine sandy loam occurs as irregular patches on the western border of the upland, being confined within a strip about five miles wide along the Mississippi bluff line. The material from which it was made is derived from the bottom land of the Mississippi and has been carried and deposited upon the bluff by the wind. It is composed largely of fine sand and various grades of silt. The total area is 20.89 square miles, or 2.46 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a brown fine sandy loam. It contains approximately 50 to 60 percent of fine sand, which gives it excellent working qualities and makes it well adapted for retaining moisture and moving it by capillarity. The organic-matter content is about 3.2 percent, or 32 tons per acre.

The natural subsurface of this type corresponds in depth to the standard sampling depth (6⅔ to 20 inches). It is a brown to yellowish brown, fine sandy loam, friable and pervious. The organic-matter content is about 2.8 percent.

The subsoil is a yellow, friable, pervious silt, containing a considerable percentage of fine sand.

Management.—This type is only fairly well supplied with the elements of plant food. It contains about 3,000 pounds of nitrogen per acre in the surface soil, and 1,000 pounds of phosphorus. The nitrogen will be used up more rapidly than the phosphorus and means should be taken to maintain or even increase the supply. Altho good crops may be grown in favorable years without paying much attention to nitrogen, yet the productiveness of the type may be decidedly increased by a little care in this regard. Farm manure, crop residues, and legumes are the means by which this element may be maintained or

increased, and the organic matter derived from these will enable the farmer to keep the soil in good tilth. There is, however, some acidity in the soil which always interferes with the growth of clover and alfalfa. In order to get the best results with legumes it is desirable even now that 2 or 3 tons of limestone per acre be applied and applications made often enough afterward to keep the soil in the best condition for growing legumes. The phosphorus content is somewhat low, and may well be increased by the application of a half-ton of rock phosphate for a number of rotations. Considered from the physical standpoint, there are very few soils in the state that are in better condition than this one; and every means should be employed to keep it up to its present standard.

(b) UPLAND TIMBER SOILS

The upland timber soils include nearly all the upland areas that are now, or have been, covered with forests. These soils contain much less organic matter than those of the prairie and hence are light brown, yellow, or gray in color. This difference is caused by the character of the vegetation that once covered them. In forests, the vegetable material (leaves and twigs from trees) accumulates upon the surface and is either burned or suffers almost complete decay. Grasses, which furnish large amounts of humus-forming roots, do not grow to any extent because of the shade of the trees. Moreover, the organic matter that had accumulated in the soil before the timber began growing is slowly removed thru various decomposition processes, with the result that in these timber soils generally the content of nitrogen and organic matter has become too low for the best growth of farm crops.

The total area of upland timber soils in Adams county is 508.65 square miles, or practically 60 percent of the area of the county.

Yellow-Gray Silt Loam (234, 534)

The yellow-gray silt loam is the most extensive type in the county, covering an area of 232.19 square miles, or 27.38 percent of the area of the county. It has been produced primarily by the long-continued growth of forests, which as a general rule developed along streams and slowly spread over the adjoining prairie. It varies in topography from flat to undulating and may be somewhat rolling where it passes into the eroded yellow silt loam (535).

The surface soil, 0 to 6⅔ inches, is a grayish yellow or brownish yellow silt loam containing from 20 to 35 percent of fine sand. It varies in physical composition to some extent, with the amount of erosion that has taken place, but in general it is quite uniform in its composition. It contains approximately 2 percent of organic matter, altho the amount of this element varies from about 1 percent, where much erosion has taken place, to 2.75 percent as it passes into the brown silt loam (–26).

The natural subsurface is from 5 to 12 inches thick and varies from a gray to a yellowish gray silt loam, passing into a clayey material. A decided change in color to that of gray usually occurs at a depth of 8 to 10 inches below the surface of the soil. The subsurface as sampled (6⅔ to 20 inches) contains approximately 1 percent of organic matter, or 20 tons per acre.

The natural subsoil begins at a depth of 12 to 18 inches. It is a yellow, grayish yellow, or brownish yellow clayey silt or silty clay that is usually rather plastic when moist.

Management.—The type is deficient in limestone, and low in organic matter, nitrogen, and phosphorus. As a rule, the soil is acid. The first requirement in its improvement is the correction of this acidity by the application of 2 to 4 tons of limestone per acre so that legumes may be grown satisfactorily. After this initial application, limestone should be applied often enough and in sufficient quantities to keep the soil in good condition for growing legumes. The condition of the soil with respect to acidity may easily be determined by making one of the tests described on pages 36 and 37.

The organic-matter and nitrogen contents are low, and since nitrogen is one of the elements contained in organic matter, any management that increases the organic-matter content will also increase the nitrogen. Crop residues, farm manures, and legumes should be turned into the soil. A rotation should be adopted that will provide for the frequent growing of legume crops. These should be largely turned under, or if fed the manure should be returned. Catch crops in grain may be used to advantage. By thus increasing the organic matter, the soil will be put in good tilth and in better condition to resist both drouth and excessive rains. The legumes that are grown are very important in another way. If the deep-rooting varieties are used, such as sweet clover, red clover, and alfalfa, the drainage conditions will be improved. Also the amount of run-off will be decreased because more water is absorbed during the rains and held in storage to serve during periods of drouth. Timothy, which is often grown as the principal crop on this kind of land, is not only of no benefit to the soil, but is actually a detriment. It would be much better to grow clover, or a mixture of clover and timothy.

The increase of the phosphorus content is very necessary. It would be well to apply from a half-ton to a ton of finely ground rock phosphate per acre once in each rotation until at least 2 or 3 tons per acre have been applied. On the more rolling parts of this type, washing is likely to occur, and here especially the organic-matter content should be increased and legumes grown. As a rule, the type does not require underdrainage, and yet there may be cases where it would be well to lay a tile in the draws to help prevent erosion.

For results from practical field experiments on yellow-gray silt loam, see page 57 of the Supplement.

Yellow Silt Loam (235, 535)

Yellow silt loam is very generally distributed over Adams county. It occurs mostly in very irregular areas as the broken and hilly land immediately adjoining the stream courses. It is very difficult to cultivate, and as a rule should be left in pasture. It is the second most extensive type in the county, covering a total of 181.13 square miles.

The surface soil, 0 to 6⅔ inches, is a yellow or brownish yellow silt loam which becomes somewhat gray upon drying after a shower. In some places erosion has exposed the yellow clayey subsoil. The stratum contains some fine

sand. The organic-matter content is low, there being about 1.8 percent, or only 18 tons per acre.

The natural subsurface is a yellow to grayish yellow silt loam, varying in thickness from 4 to 10 inches. This variation in depth is largely the result of erosion, and in some places the subsurface may be made up of the same material as the subsoil. The stratum sampled (6⅔ to 20 inches) contains about .6 percent of organic matter, or 12 tons per acre.

The natural subsoil is sometimes exposed on the surface in small patches where erosion has taken place, but it usually begins at a depth of 10 to 16 inches and is a yellow clayey silt or silty clay. In some places in part of its depth it partakes of the character of fine sandy loess, while in other places the subsoil to a depth of 40 inches may be made up of glacial till, which here is usually a heavy clay with some sand and fine gravel. It contains about .4 percent of organic matter.

Management.—Altho the total area of yellow silt loam is large, making up more than a fifth of the county, it is of little importance agriculturally because most of it is so hilly as to render its cultivation either extremely difficult or else impossible. It is therefore devoted almost entirely to pasture. Some areas might be cultivated were it not for the danger of loss from erosion. Even if the land is cleared and put under cultivation, its life under the ordinary methods of cultivation is only a few years. It then becomes practically unproductive. It is one of the most difficult soils in the state to manage.

This type in general is low in practically all the elements of plant food except potassium. It is also decidedly acid, particularly in the subsurface. With present methods it is of little use to apply plant food, because it would be washed away in a short time. It is, however, desirable to apply limestone at the rate of 3 or 4 tons per acre in order to furnish the best conditions for the growing of legumes, which are the best crops for preventing erosion. The amount of pasture produced on this hilly land may be greatly increased by the application of limestone and the growing of sweet clover. Sweet clover provides a large amount of excellent pasture and even the growth of blue grass will be greatly encouraged by the nitrogen that is furnished by the sweet clover. If the land is to be cultivated, sweet clover will add organic matter and will help to retain the soil. Thru the penetration of its roots it will loosen all strata of the soil so that much more water will be absorbed, thus preventing a large amount of run-off. The water that is absorbed into the soil is always of benefit, while that which runs off is always detrimental. All gullies that start in the field should be put under control at once. Probably the best way to do this is to fill them, apply limestone, and sow to sweet clover. A surface application of manure or straw may be necessary in order to prevent erosion until the sweet clover gets a start. (See Bulletin 207, Washing of Soils and Methods of Prevention). For methods of improving yellow silt loam, see the discussion of the Vienna experiment field on page 60 of the Supplement.

Yellow-Gray Fine Sandy Loam (874)

Yellow-gray fine sandy loam is found only in the deep loess area, which is within five miles of the Mississippi bluff. The topography is undulating to

slightly rolling. The total area is 56.18 square miles, or 6.63 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a light brown to yellow fine sandy loam containing about 2.2 percent of organic matter, or 22 tons per acre.

The natural subsurface varies from 4 to 10 inches in thickness and is a yellow to a light brownish yellow fine sandy loam. The stratum as sampled (6⅔ to 20 inches) contains about 1.7 percent of organic matter, or 34 tons per acre.

The subsoil is a yellow fine sandy silt, friable and porous, and contains about .6 percent of organic matter.

Management.—This type is sufficiently undulating for good drainage. It is an excellent soil in its texture, but it is somewhat low in organic matter, nitrogen, and phosphorus. It is becoming acid, and if legumes are to be grown satisfactorily limestone must be applied at the rate of 2 to 3 tons per acre, the applications to be repeated as the soil requires. The growing and turning under of legumes, together with the farm manure and crop residues, will increase the content of organic-matter and nitrogen and will keep the soil in good physical condition.

It will soon be necessary to begin the application of phosphate, and this may give good results even now. Finely ground rock phosphate should be applied at the rate of a half-ton to a ton per acre every five or six years until the amount of phosphorus now present in the soil is almost doubled.

There are some places where washing will take place to an injurious extent unless measures are taken to prevent it. This can be largely prevented by growing legumes, by incorporating organic matter, and by keeping a cover crop on the land as much as possible.

Yellow Fine Sandy Loam (875)

Yellow fine sandy loam occurs in the deep loess area and along the stream courses. There is not so much eroded land in the sandy area along the streams in the western part of the county as is found in the more silty land along the streams in the eastern part. This is due, probably, to the greater porosity of the soil, which allows it to absorb moisture, and thus diminishes the run-off. The total area of this type is 30.78 square miles, or 3.63 percent of the area of the county. The topography is hilly and in many places very steep. This land should be cultivated only with the greatest care.

The surface soil, 0 to 6⅔ inches, is a yellow to light brownish yellow fine sandy loam containing about 1.4 percent of organic matter, or 14 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a yellow, slightly clayey silt containing about .7 percent of organic matter, or 14 tons per acre.

The subsoil is a yellow clayey silt containing .5 percent of organic matter.

Management.—The first requisite in the improvement of this type is the application of about 3 tons of limestone per acre. This soil is acid, especially in the surface and subsurface, and the limestone is necessary in order to correct the acidity and put the soil into condition for growing clovers. The content of nitrogen and organic matter is very low, and crop residues, legumes, and farm

manure should be turned under in order to increase these constituents. The total nitrogen content of the plowed soil is only 1,500 pounds per acre, which is entirely too low for profitable crops. It would be well to grow sweet clover or some other legume crop two or three years out of every four. Legumes may be grown as catch crops, even when the regular crop is grown. Sweet clover may be seeded in wheat and the year's growth turned under for corn; corn may be followed by soybeans, and that by wheat. Or any similar rotation may be used in which the legume is grown frequently.

The phosphorus content of the surface soil is only 600 pounds per acre; this should be augmented as rapidly as possible. The best plan is to apply a half-ton to a ton of finely ground rock phosphate per acre once in each rotation.

This type is better adapted to pasture than to anything else because of the difficulty of cultivation and of preventing washing. The suggestions which were made under yellow silt loam (535) for preventing washing will apply here also. See Bulletin 207, Washing of Soils and Methods of Prevention.

Yellow Sandy Loam (265, 565)

Yellow sandy loam occurs in eroded areas. There is a region in the southern part of the county in Townships 2 and 3 South, Ranges 6 and 7 West, in which the deeper subsoil is composed of sand. Where erosion has occurred, especially on the slopes, the sand is exposed, and this gives rise to the sandy loam type. The sand is either gray or bright yellow in color. The type covers an area of 8.37 square miles, or .99 percent of the total area of the county. In topography it is hilly and on the whole is very poor for agricultural purposes.

The surface soil, 0 to 6⅔ inches, is a yellow or brownish yellow sandy loam containing about 1.5 percent of organic matter, or 15 tons per acre. The sand is medium in grade and varies widely in amount.

The subsurface soil, 6⅔ to 20 inches, is a light brownish yellow to grayish yellow sandy loam containing about .9 percent of organic matter.

The subsoil is a reddish to grayish sand, usually much coarser than that of the surface. Sometimes this stratum contains a layer of grayish clay or a mixture of clay and sand.

Management.—The topography of this type prevents its being used to any extent for agricultural purposes other than pasturing. Even for this purpose it may be improved to a considerable extent by applications of limestone and rock phosphate. The soil is somewhat acid, and an application of 2 or 3 tons of limestone per acre should be made. The phosphorus content is very low, being only about 450 pounds per acre in the plowed soil, and in the subsurface and subsoil even less. Finely ground rock phosphate should be applied in amounts of about one-half to one ton per acre until the present phosphorus content in the surface soil is well built up. Acid phosphate may be used satisfactorily. The nitrogen content is low, amounting only to about 1,600 pounds per acre. To correct this condition, legumes should be grown and turned under, together with crop residues and farm manure.

(c) TERRACE SOILS

Terrace soils usually occur along streams. They were formed at a time when the streams, owing to melting glacier ice, were much larger than they are at present, and carried large amounts of coarse material, such as sand and gravel. Upon any decrease in their velocity, these overloaded streams deposited debris along their courses. This resulted in the partial filling of the valley and the formation of what are now the terraces, bench lands, or second bottom lands. Finer material later deposited over this sand and gravel forms the present soil. When the streams become reduced to their normal size after the glacier had melted, they began cutting down thru this deposit, and the beds of the streams are now so low that the terraces, or benches, do not overflow.

In Adams county, as a rule, the deposit of gravel or sand usually found in terraces is comparatively thin. It may be covered so deep by fine material (4 to 8 feet) as to have but little effect on drainage. The value of some terrace soils, however, is impaired by the nearness of the gravel to the surface, in which case the soil is unable to resist drouth. This difficulty, however, does not exist in Adams county. The total area of terrace lands in the county is only 4.05 square miles, or .47 percent of the area of the county.

Brown Silt Loam (1526)

The terrace brown silt loam occupies only .18 square miles, or 115 acres. It is found along Mill creek. The topography is slightly undulating.

The surface soil, 0 to 6⅔ inches, is a brown silt loam differing but little, except in origin, from that of the upland. It contains about 3.4 percent of organic matter, or 34 tons per acre.

The natural subsurface extends from a depth of 6⅔ to about 17 inches. It is a brown silt loam, becoming lighter in color with increasing depth. The stratum sampled (6⅔ to 20 inches) contains about 2.1 percent of organic matter, or 42 tons per acre.

The subsoil varies from a yellow clayey silt to a yellow silt. It is friable and porous, and contains about 1.1 percent of organic matter.

Management.—This type is practically the same as the upland brown silt loam (226 and 526) in its limestone, organic-matter, and phosphorus requirements and should be managed in essentially the same manner.

Brown Sandy Loam (1560)

The terrace brown sandy loam occurs in the Mississippi bottoms in Township 3 South, Range 8 West, and comprizes an area of 493 acres. It is elevated from 20 to 25 feet above the ordinary bottom land of the Mississippi. It is slightly undulating, as a result perhaps of wind action.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam containing some coarse sand and fine gravel. The organic-matter content is about .9 percent, or only 9 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a brown sandy loam containing coarse sand and fine gravel. It differs from the surface soil in that it has slightly more organic matter (a content of 1 percent). This condition occasionally

occurs in sandy loams; there is a downward leaching of plant food from the surface to the subsurface, and consequently there is a greater accumulation of plant roots in the subsurface.

The subsoil is coarser than the subsurface stratum, containing more fine gravel. It is of a yellowish color.

Management.—About the only factor to be considered in the management of this soil for the present is the need of organic matter and nitrogen. In order to supply these elements, it may be necessary to apply limestone so that legumes may be grown more satisfactorily. After limestone is applied, alfalfa ought to grow well. A good supply of organic matter will tend to improve this soil in its power to retain moisture and will also prevent the sand particles from being so readily shifted by the wind.

Brown-Gray Silt Loam on Tight Clay (1528)

Brown-gray silt loam on tight clay occurs in a few small areas, the largest being along Mill creek. The total area amounts to but 128 acres. The topography is flat to slightly undulating.

The surface soil, 0 to 6⅔ inches, is a brown or grayish brown silt loam containing a small amount of sand. The organic-matter content is about 1.5 percent, or 15 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a gray to yellowish gray silt loam. It contains about 1.1 percent of organic matter.

The subsoil, 20 to 40 inches, varies from an ordinary gray silt to a clayey silt, becoming more clayey at a depth of 36 to 38 inches. The subsoil is not so compact and impervious as is the subsoil of the same type as it occurs in the upland.

Management.—This type in general is fairly well drained, but it is low in nearly all the elements of plant food. It therefore needs to be increased in organic matter and nitrogen, and for this purpose crop residues, farm manure, and legumes should be turned under. However, before the best results can be secured with clovers, it will be necessary to apply 2 to 3 tons of limestone per acre. Phosphorus should be applied at the rate of about one-half ton of finely ground rock phosphate per acre every four or five years. If this course is followed, a system will be established which in a few years will result in the growing of better crops and, at the same time, will put the soil in better tilth.

Yellow-Gray Silt Loam (1534)

Yellow-gray silt loam is found along Bear and Mill creeks. The individual areas are not large, but the total area amounts to 1,395 acres, or .26 percent of the area of the county. The topography is flat to undulating.

The surface soil, 0 to 6⅔ inches, is a gray to yellowish gray silt loam containing a perceptible amount of fine sand. It contains approximately 1.7 percent of organic matter.

The subsurface soil, 6⅔ to 20 inches, varies from a gray to a light gray silt loam. It contains about 1 percent of organic matter.

The subsoil, 20 to 40 inches, is a gray silt, changing to a silty clay at 22 to 24 inches.

Management.—The first requirement in the improvement of this soil is the application of 2 to 4 tons of limestone per acre. This should be followed by the incorporation of crop residues and barnyard manure, and by the growing of legumes. The legumes should not be removed from the land entirely, but should either be turned under or the manure produced from them should be saved and applied to the soil. Legumes are especially well adapted for benefiting this soil because of the fact that the roots will open up the subsoil and increase the facilities for drainage. Sweet clover is more desirable than any other legume except perhaps alfalfa. After a good crop of sweet clover has been grown, there will be little difficulty in getting alfalfa to take hold. The nitrogen content is only about 1,700 pounds per acre in the plowed soil, which is too low for a good productive soil, but the growing of legumes and the turning under of other forms of organic matter will soon increase the nitrogen content sufficiently. It would be well to apply a half-ton of rock phosphate per acre every four or five years for a number of rotations.

Yellow-Gray Silt Loam Over Gravel (1536)

Yellow-gray silt loam over gravel occurs particularly along Mill creek in the southern part of the county. In the formation of this type sufficient gravel has been deposited to furnish satisfactory drainage. The total area of the type is only 397 acres.

The surface soil, 0 to 6⅔ inches, varies from a light brown to a yellow-gray silt loam. It contains about 1.6 percent of organic matter, or 16 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a gray silt loam containing about .6 percent of organic matter, or 12 tons per acre.

The subsoil is a gray silt.

Management.—The drainage of this type is good. In other respects it requires essentially the same treatment as the preceding type (1534).

Yellow-Gray Sandy Loam (1564)

Only one area of yellow-gray sandy loam is found. It comprizes but 64 acres and is located in Section 10, Township 2 South, Range 8 West, along Mill creek. This type is low in all the elements of fertility and organic matter and is becoming decidedly acid. Essentially the same treatment should be applied to this soil as that recommended for yellow-gray silt loam (1534).

(d) OLD BOTTOM-LAND SOILS

The bottom lands of the state are divided into the old, or early-formed areas, and those that have been formed more recently. As a rule, the more recently formed areas have the best soil. This is especially true of those that are located in the bottom lands along the larger streams. Of the old bottom-land soils, Adams county has 65.83 square miles, classified under two types: brown-gray silt loam on tight clay (1328), and mixed loam (1354).

Brown-Gray Silt Loam on Tight Clay (1328)

Brown-gray silt loam on tight clay is found in the bottom lands of the Mississippi. It occupies a total area of 4.95 square miles, or .58 percent of the area of the county. The largest amount is in the region just south of Lima lake.

The surface soil, 0 to 6⅔ inches, is a brown or grayish brown silt loam containing about 3.1 percent of organic matter, or 31 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a brown silt loam changing at 8 to 10 inches to a gray silt loam that is somewhat impervious. It contains about 1.6 percent of organic matter.

The subsoil, 20 to 40 inches, is a gray silt with some brown iron mottlings. It contains about .4 percent of organic matter. A heavy, compact, stratum of clay occurs at a depth of about 36 inches.

Management.—The topography of this type is flat. It is therefore necessary to provide some form of drainage. The soil is of such a character that it will tile-drain fairly well. It is fairly well supplied with organic matter and nitrogen, but the present amounts must be maintained if the productiveness of the soil is to be continued. The type is becoming acid and will require the application of about 2 to 3 tons of limestone per acre in order to put it in the best condition for growing legumes. Crop residues should be turned under. It will probably not be necessary to apply phosphate at once, but a few years of cropping, especially since overflow is prevented by a levee so that there can be no deposition of soil material, will soon make the application of phosphorus necessary.

Mixed Loam (1354)

Mixed loam occurs along the small streams in the upland as narrow strips of bottom land which rarely exceed 100 rods in width. They are subject to frequent overflow but the water does not stay on long. Usually a large amount of sediment is carried, which is deposited to a greater or less extent over the flood plain. New channels are frequently developed, thus giving the type a slightly undulating topography. The soil varies widely, and for this reason it is impossible to separate it into distinct types based on physical composition. The total area in the county is 60.88 square miles, or 7.18 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, varies from a sand to a brown silt loam, or even to a brown clayey silt loam. The next flood may entirely change the character of the soil, and it is therefore impossible to make a satisfactory classification, even on a very large scale. The organic-matter content of the sample taken was about 2.4 percent, or 24 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a brown mixed loam, varying in about the same way as the surface soil. It contains, as sampled, about 1.8 percent of organic matter.

The subsoil, 20 to 40 inches, varies from a brown or yellowish sand to a sandy silt loam. The subsoil presents as great or even greater variations than does the subsurface.

Management.—The type in general is kept fairly well supplied by overflow with the elements of plant food; about the only requirement that need be considered is good cultivation.

(e) LATE SWAMP AND BOTTOM-LAND SOILS

Six types of soil constitute the group designated as the late swamp and bottom lands. They occupy, all told, an area of 82.83 square miles, or nearly 10 percent of the area of the county.

Brown Silt Loam (1426)

The brown silt loam of the Mississippi bottoms (in which is included practically all of this type) is distributed along the length of the county inside of the levee. The topography is flat to slightly undulating. The total area in the county is 33.95 square miles.

The surface soil, 0 to 6⅔ inches, varies from a light brown to a dark brown silt loam. It frequently contains some fine sand that has been derived from the wind-blown material washed down from the upland. The organic-matter content is about 2.4 percent, or 24 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a light to very dark brown silt loam containing fine sand. It has an organic-matter content of 1.9 percent, or 38 tons per acre.

The subsoil, 20 to 40 inches, varies from a yellow to a brown silt loam, often containing more organic matter than either of the other strata. This is due to the fact that material has been deposited upon and has buried an old soil rich in organic matter. This condition is found especially when the type occurs near the bluff or near a stream from the bluff.

Management.—One of the greatest difficulties in the management of this type is to prevent overflow. Levees have been built along the Mississippi and along the larger streams from the upland, such as Bear, Mill, and Rock creeks. Even at the best, however, a levee will break occasionally and cause an overflow. The type is fairly well supplied with the elements of plant food; and as long as overflow continued, the deposits were sufficient to replace the plant food removed by cropping. Since this source of plant food no longer exists, it may be necessary in the course of time to begin the application of plant-food materials. The organic-matter content is not very high; and with its constant removal thru decomposition, steps should be taken looking to its maintenance and possibly to its increase. For this purpose, crop residues, farm manure, and legumes should be plowed under. This will increase the amount of organic matter, and so improve the tilth, and will increase also the amount of nitrogen. The phosphorus content, too, is rather low, and the application of that element will become necessary in time. By applying a half-ton of finely ground rock phosphate every four or five years, the phosphorus supply will be not only maintained but actually increased. The soil is becoming very low in limestone, and acidity is developing. Ground limestone should be applied in amounts depending upon the amount of acidity present.

Brown Sandy Loam (1460)

Brown sandy loam is distributed generally thruout the Mississippi bottom land. It covers an area of 6.54 square miles, or .77 percent of the area of the county. In topography it is flat to very slightly undulating.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam with varying amounts of sand and organic matter, the latter averaging about .9 percent, or 9 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a brown sandy loam containing about .8 percent of organic matter.

The subsoil, 20 to 40 inches, is a slightly loamy yellow sand, mostly medium in grade.

Management.—The amount of sand in this type is sufficient to keep the soil in good workable condition. The organic-matter content is very low, which means also a low nitrogen content. The analyses show that this soil contains only about 1,200 pounds of nitrogen per acre in the surface stratum, which is far too low for a good, productive soil. In order to increase the content of organic-matter and nitrogen and to provide better physical conditions, legumes, farm manure, and crop residues should be turned under. The soil is becoming somewhat acid, and it may be necessary to apply 1 or 2 tons of crushed limestone per acre in order to get best results with clovers. The phosphorus content in the plowed soil is about 900 pounds per acre, which is probably sufficient for producing good crops on a soil of this texture. However, there is no question but that in a short time it will be necessary to apply phosphorus in some form. Probably the most economical form in which to apply it is that of finely ground raw rock phosphate; about one-half ton per acre should be applied in each rotation for several rotations.

Drab Clay (1415)

Drab clay is well distributed in the Mississippi bottoms, usually occurring some distance back from the river. It has been formed where there has been very little current, so that only the finest material has been carried in and deposited. The topography is flat. The formation taking place at present in Lima lake probably represents the method of formation of this type, altho such extensive lakes probably did not exist at the time this particular type was being formed. The total area of drab clay in the county is 8.68 square miles, or 1.02 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a dark brown to light drab clay. It varies in physical composition, especially in the amount of sand present. Where this sand occurs in areas of sufficient size, it is mapped as sandy drab clay loam. The surface soil contains 3.1 percent of organic matter, or 31 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a drab clay, becoming slightly lighter in color with increasing depth. It varies in somewhat the same way as does the surface. It contains about 1.8 percent of organic matter, or 36 tons per acre.

The subsoil, 20 to 40 inches, is a drab clay. It contains about 1 percent of organic matter.

Management.—The great difficulty in the management of this type is found in its tendency to form clods, as a result of puddling. Fortunately, however, it possesses the property of granulation, without which cultivation would be practically impossible. Frequently when the land is plowed, it is cloddy, and a shower followed by drying will develop granulation, or the formation of crumbs, or, as it is frequently expressed, the soil "slakes." If the soil is worked at this time, it becomes mellow and is easily put into fine condition. The presence of limestone and organic matter aid in the process of granulation. A sufficient supply of these materials should be maintained for that purpose, as well as for their other beneficial effects. To furnish the requisite organic matter, crop residues and legumes should be turned under. This soil is fairly well supplied with the elements of plant food, altho the amount of nitrogen could well be increased. It is desirable that thoro cultivation be practiced in order to stimulate the process of nitrification, or the formation of available nitrates for the crop. Another essential factor calling for consideration in the management of this type is drainage. As a rule, this type in Adams county drains well, the only great difficulty being the securing of an outlet. Thru the process of checking or cracking, passage ways are developed in the soil which permit the ready movement of water. It would, however, be beneficial to the soil if deep-rooting legumes were grown. These would not only give a larger supply of nitrogen but would also open up the soil to a greater depth. The soil is becoming somewhat acid, and it may be necessary to apply 1 or 2 tons of limestone per acre in order to secure best results with legumes.

Drab Clay Loam (1421)

Drab clay loam is rather closely associated with drab clay and often grades into that type. It embraces 15.96 square miles or 1.88 percent of the total area of the county. Its origin is practically the same as that of the preceding type.

The surface soil, 0 to 6⅔ inches, is a light brown to a drab clay loam, varying toward a sandy phase on the one hand and toward a drab clay on the other. It contains about 3.3 percent of organic matter, or 33 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a brown to drab heavy clay loam. It contains approximately 2.1 percent of organic matter, or 42 tons per acre.

The subsoil, 20 to 40 inches, varies in color from light to dark drab and in texture from a clayey silt to a silty clay.

Management.—This type is a little better provided with nitrogen and phosphorus than the drab clay, but its management should be about the same as for that type. It is becoming acid and in a few years, if not at the present time, the application of a ton or two of limestone per acre will be necessary in order to get the best results with legumes. This is especially true since the building of the levees, which have largely prevented overflow. Good cultivation is essential for this type also. The property of granulation is very desirable and should be encouraged by good drainage and the supplying of limestone and organic matter.

Sandy Drab Clay Loam (1421.1)

Sandy drab clay loam occurs in a few small areas in different parts of the Mississippi bottom land. The total area covered is 192 acres. It passes into drab clay loam (1421).

The surface soil, 0 to 6⅔ inches, is a dark drab sandy clay loam containing about 4.6 percent of organic matter, or 46 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is also a dark drab sandy clay loam with the sand distributed somewhat in strata, indicating perhaps the effect of different periods of overflow. This subsurface stratum contains about 2 percent of organic matter.

The subsoil is very similar in character to the subsurface.

Management.—The management as discussed for the two preceding types will apply here also.

Mixed Loam (1454)

Mixed loam is found in the Mississippi bottoms and comprizes the area outside of the levee. It is of very little importance agriculturally, except on part of Long island, which is under cultivation. There is always danger of overflow, and whenever this occurs changes are produced in the character of the soil. At one time the soil deposited may be a heavy clay, while at other times in the same region it may be almost pure sand. The total area of this type is 17.40 square miles, or 2.05 percent of the area of the county.

The type is usually well supplied with plant food. Altho it is not very high in food elements, yet the deposit of new material from overflow is sufficient to maintain the supply of plant food indefinitely.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to intelligently interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification here used.

The unit in the soil survey is the soil type, and each type possesses more or less definite characteristics. The line of separation between adjoining types is usually distinct, altho sometimes one type grades into another so gradually that it is very difficult to draw the line between them. In such exceptional cases, some slight variation in the location of soil-type boundaries is unavoidable.

In establishing soil types several factors must be taken into account. These are: (1) the geological origin of the soil, whether residual, cumulose, glacial, eolial, alluvial, or colluvial; (2) the topography, or lay of the land; (3) the native vegetation, as prairie grasses or forest; (4) the depth and the character of the surface, the subsurface, and the subsoil, as to the percentages of gravel, sand, silt, clay, and organic matter which they contain, their porosity, granulation, friability, plasticity, color, etc.; (5) the natural drainage; (6) the agricultural value, based upon its natural productiveness; (7) the ultimate chemical composition and reaction.

Great Soil Areas in Illinois.—On the basis of the first of the above mentioned factors, namely, the geological origin, the state of Illinois has been divided into seventeen great soil areas with respect to their geological formation. The names of these areas are given in the following list along with their corresponding index numbers, the use of which is explained below. For the location of these geological areas, the reader is referred to the general map published in Bulletins 123 and 193.

000 *Residual*, soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated*, comprizing three areas, the largest being in the south end of the state
200 *Illinoisan moraines*, including the moraines of the Illinoisan glaciations
300 *Lower Illinoisan glaciation*, covering nearly the south third of the state
400 *Middle Illinoisan glaciation*, covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation*, covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation*, but now believed to be part of the upper Illinoisan
700 *Iowan glaciation*, lying in the central northern end of the state
800 *Deep loess areas*, including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines*, including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines*, including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation*, covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation*, lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands*, found in the older or Illinoisan glaciation
1400 *Late river-bottom and swamp lands*, those of the Wisconsin and Iowan glaciations
1500 *Terraces*, bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits*, formed by Lake Chicago, the enlarged glacial Lake Michigan

Mechanical Composition of Soils.—The mechanical composition, or the texture, is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents:

Organic matter: undecomposed and partially decayed vegetable material
Inorganic matter: clay, silt, fine sand, sand, gravel, stones

Classes of Soils.—Based upon the relative proportion of the various constituents mentioned above, soils may be grouped into a number of well recognized classes. Following is a list of these classes, arranged according to their index numbers, the use of which is explained below:

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

Naming and Numbering Soil Types.—The naming of soil types has been the subject of much discussion, and practice varies considerably in this matter. In this soil survey of Illinois a system of classification and naming has been adopted which is based upon the various considerations presented in the preceding paragraphs.

After texture, one of the most striking characteristics of a soil is the color. Therefore, in the naming of soils in Illinois, a combination of color and texture, together with other descriptive terms when necessary, has been adopted so that the name in itself carries a definite description of a given soil type; as for example, "gray silt loam on tight clay," or "brown silt loam over gravel." The use of the prepositions *on* and *over* serves to indicate the presence of certain substrata. When the surface soil is underlain with material such as sand, gravel, or rock, the word *over* is used if this material lies at a depth greater than 30 inches; if it is less than 30 inches, the word *on* is used.

For further identification of soil types a system of numbering, resembling somewhat the Dewey library system, has been adopted whereby each soil type is assigned a certain number. This number indicates at once the geological origin of the soil as well as its physical description. The digits of the order of hundreds represent the geological area where the soil is found, beginning with 000, the residual, followed by 100, the unglaciated, and the rest of the series in the order of the enumeration presented in the paragraph above headed *Great Soil Areas in Illinois*. The digits of the orders of units and tens represent the various kinds of soil such as are enumerated above in the list of soil classes. Certain modifications are designated in this system by a figure placed at the right of the decimal point. To illustrate the working of this numbering system, suppose a soil type bears the number 726.5. The number 7 indicates that this soil occurs in the Iowan glaciation, the 26 that it is a brown silt loam, and the .5 that rock

is found less than 30 inches below the surface. These numbers are especially useful in designating small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports.

SOIL SURVEY METHODS

Mapping the Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. In order that the survey be thoroly trustworthy it is necessary that careful, well-trained men be employed to do the mapping. The work is prosecuted to the best advantage by working in parties of from two to four. Only such men are placed in charge of these parties as are thoroly experienced in the work and have shown themselves to be especially well qualified in training and ability.

The men must be able to keep their location exactly and to recognize the different soil types, with their principal variations and limits, and they must show these upon the maps correctly. A definite system is employed in checking up this work. As an illustration, one man will survey and map a strip 80 rods or 160 rods wide and any convenient length, while his associate will work independently on another strip adjoining this area, and if the work is correctly done the soil-type boundaries will match up on the line between the two strips.

An accurate base map for field use is absolutely necessary for soil mapping. The base maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as a basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil-type boundaries, together with the streams, roads, railroads, canals, and town sites are placed in their proper locations upon the map while the mapper is on the area. Each section, or square mile, is divided into 40-acre plots on the map, and the surveyor must inspect every ten acres and determine the type or types of soil thereon. The different types are indicated on the map by different colors, pencils for this purpose being carried in the field.

A small auger 40 inches long forms for each man an invaluable tool with which he can quickly secure samples of the different strata for inspection. An extension for making the auger 80 inches long is taken by each party, so that any peculiarity of the deeper subsoil layers may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by a speedometer or by some other measuring device, while distances in the field away from the roads are determined by pacing, an art in which the men become expert by practice. The soil boundaries can thus be located with as high a degree of accuracy as can be indicated by pencil on the scale of one inch to the mile.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. For this purpose usually three strata are sampled; namely, the surface (0 to 6⅔ inches), the subsurface (6⅔ to 20 inches), and the subsoil

(20 to 40 inches). These strata correspond approximately, in the common kinds of soil, to 2,000,000 pounds of dry soil per acre in the surface layer, and to two times and three times this quantity in the subsurface and the subsoil, respectively. This is, of course, a purely arbitrary division, very useful in arriving at a knowledge of the quantity and the distribution of plant food in the soil, but it should be noted that these strata do not necessarily coincide with the natural strata as they actually exist in the soil, and which are referred to in describing the soil types.

By this system of sampling we have represented separately three zones for plant feeding. The surface layer includes at least as much soil as is ordinarily turned with the plow. This is the part with which the farm manure, limestone, phosphate, or other fertilizer applied in soil improvement is incorporated, and which must be depended upon in large part to furnish the necessary plant food for the production of crops. A rich subsoil has little or no value if it lies beneath a worn-out surface, but if the fertility of the surface soil is maintained at a high point, then the strong vigorous plants will have power to secure more plant food from the subsurface and subsoil.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. Even tho plowed alike and at the same time, prepared the same way, planted the same day with the same kind of seed, and cultivated alike, watered by the same rains and warmed by the same sun, nevertheless the best acre may produce twice as large a crop as the poorest acre on the same farm, if not, indeed, in the same field; and the fact should be repeated and emphasized that with the normal rainfall of Illinois the productive power of the land depends primarily upon the stock of plant food contained in the soil and upon the rate at which it is liberated, just as the success of the merchant depends primarily upon his stock of goods and the rapidity of sales. In both cases the stock of any commodity must be increased or renewed whenever the supply of such commodity becomes so depleted as to limit the success of the business, whether on the farm or in the store.

CROP REQUIREMENTS

Ten different elements of plant food are essential for the growth and formation of every plant. These elements are: *carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, magnesium, calcium, and iron;* and they are represented by the chemical symbols: C, O, H, N, P, S, K, Mg, Ca, and Fe. Some seasons in central Illinois are sufficiently favorable to allow the production of at least 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. When such crops, growing under favorable climatic and cultural conditions and uninjured by disease or insect pests, are not produced the failure is due to unfavorable soil condition, which may result from poor drainage, poor physical condition, or from an actual deficiency of plant food.

Table A shows the plant-food requirements of some of our most common field crops with respect to the seven elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a

TABLE A.—PLANT FOOD IN WHEAT, CORN, OATS, AND CLOVER

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain......	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat, straw.....	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain.......	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover.......	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs........	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain.......	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw........	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed.......	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay.......	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00

ton, as the case may be. From these data the amount of any element removed from an acre of land by a crop of a given yield can easily be computed.

It needs no argument to show that the continuous removal of such quantities of plant food without provision for their replacement must result sooner or later in soil depletion.

PLANT-FOOD SUPPLY

Of the ten elements of plant food, three (*carbon, oxygen,* and *hydrogen*) are secured from air and water, and seven from the soil. *Nitrogen,* one of these seven elements obtained from the soil by all plants, may also be secured from the

TABLE B.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure..............................	10	2	8
Corn stover..............................	16	2	17
Oat straw..............................	12	2	21
Wheat straw..............................	10	2	18
Clover hay..............................	40	5	30
Cowpea hay..............................	43	5	33
Alfalfa hay..............................	50	4	24
Sweet clover (water-free basis)[1]..............	80	8	28
Dried blood..............................	280	...	...
Sodium nitrate..............................	310	...	...
Ammonium sulfate..............................	400	...	...
Raw bone meal..............................	80	180	...
Steamed bone meal..............................	20	250	...
Raw rock phosphate..............................	...	250	...
Acid phosphate..............................	...	125	...
Potassium chlorid..............................	...	...	850
Potassium sulfate..............................	...	...	850
Kainit..............................	...	...	200
Wood ashes[2]..............................	...	10	100

[1]Young second year's growth ready to plow under as green manure.
[2]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

air by one class of plants (legumes), in case the amount liberated from the soil is insufficient; but even these plants (which include only the clovers, peas, beans, and vetches among our common agricultural plants) are dependent upon the soil for the other six elements (*phosphorus, potassium, magnesium, calcium, iron,* and *sulfur*), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to nearly 33,000 pounds. In like manner the phosphorus content varies from about 420 to 4,900 pounds, the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table B is presented for the purpose of furnishing information regarding the quantity of plant food contained in some of the materials most commonly used as sources of plant-food supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of fertility actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such plant foods as calcium and phosphorus, converting them into available forms of food for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral foods are liberated for the benefit of the cereal crops which follow in the rotation, and which are less independent feeders. Moreover, as an effect of the deep rooting habit of these legumes, large quantities of mineral plant foods are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and thus encourages the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the insoluble and unavailable organic nitrogen into soluble and available nitrate nitrogen. At the

same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium, and also to dissolve the insoluble phosphate and limestone which may be applied in low-priced forms. Thus, in the conversion of sufficient organic nitrogen into nitrate nitrogen for a 100-bushel crop of corn, the nitrous acid formed is alone sufficient to convert seven times as much insoluble tricalcium phosphate into soluble monocalcium phosphate as would be required to supply the phosphorus for the same crop.

Organic Matter and Biological Action.—Organic matter may be supplied by animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant food than the 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the *ratio of carbon to nitrogen.* Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing soluble phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant food by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant food is concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides the plant food calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by preventing the growth of certain fungus diseases, such as corn root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement.

Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands. Remarkable success has been experienced with limestone used in conjunction with sweet clover in the reclamation of abandoned hill land which had been ruined thru erosion.

Amounts to Apply.—If the soil is acid, usually at least 2 tons per acre of ground limestone should be applied as an initial treatment. Continue to apply limestone from time to time according to the requirement of the soil as indicated by the tests described below, or until the most favorable conditions are established for the growth of legumes, using preferably at times magnesian limestone ($CaCO_3MgCO_3$), which contains both calcium and magnesium and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone ($CaCO_3$). On strongly acid soils, or on land being prepared for alfalfa, 4 or 5 tons per acre of ground limestone may well be used for the first application.

How to Ascertain the Need for Limestone.—The need of a soil for limestone may be ascertained by applying one of the following tests for soil acidity. Along with the acidity test, a test for the presence of carbonates should be made. It should be understood that a positive test for carbonates does not guarantee the absence of acid; for it may happen, especially when the soil is near the neutral point, that positive tests for both acidity and carbonates are obtained. This condition is explained by the assumption that solid particles of calcium or magnesium carbonates form centers of alkalinity within a soil that is generally acid. Because of this fact any test made of a given soil ought to be repeated if it is to be thoroly reliable. It is also desirable to test samples from different depths. Following are the directions for making these tests:

The Litmus Paper Test for Acidity. Make a ball of fresh moist soil, break it in two, insert a piece of blue litmus paper, and press the soil firmly together. After a few minutes examine the paper. If it has turned pink or red, soil acidity is indicated. The intensity of the color and the rapidity with which it develops indicates to some extent the amount of acidity. Needless to say the reliability of the test depends upon the quality of litmus paper used.

The Potassium Thiocyanate Test for Acidity. A more recently discovered test for soil acidity which promises to be more satisfactory than the litmus test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol (not denatured). When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. The conditions for a prompt reaction require a temperature that is comfortably warm.

The Hydrochloric Acid Test for Carbonates. Make a shallow cup of a ball of soil and pour into it a few drops of concentrated hydrochloric acid. If carbonates are present they are decomposed with the liberation of carbon dioxid, which appears as gas bubbles, producing foaming or effervescence. With much carbonate present the action is lively, but with mere traces of it the bubbles are given off slowly. If no carbonate, or very little, is indicated by the test, then it is advisable to apply limestone.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for agricultural uses. *These are the chemical and the biological fixation of the atmospheric nitrogen.* Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of those legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for feed and seed as well as for nitrate production, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen, the possibilities of which now represent numerous compounds, will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes.

For easy figuring it may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpeas contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of a soil varies according to its origin and the kind of farming practiced. Even virgin soils are found that are deficient in phosphorus.

On all lands deficient in phosphorus (except on those susceptible to serious erosion by surface washing or gullying) that element should be applied in considerably larger amounts than are required to meet the actual needs of the crops desired to be produced. The abundant information thus far secured shows positively that finely ground natural rock phosphate can be used successfully and very profitably, and clearly indicates that this material will be the most economical form of phosphorus to use in all ordinary systems of permanent, profitable soil improvement. The first application may well be one ton per acre, and subsequently about one-half ton per acre every four or five years should be applied, at least until the phosphorus content of the plowed soil reaches 2,000 pounds per acre, which may require a total application of from 3 to 5 or 6 tons per acre of raw phosphate containing 12½ percent of the element phosphorus.

Steamed bone meal and even acid phosphate may be used in emergencies, but it should always be kept in mind that a pound of phosphorus delivered in Illinois in the form of raw phosphate (direct from the mine in carload lots), is much cheaper than the same amount in steamed bone meal or in acid phosphate, both of which cost too much per ton to permit their common purchase by farmers in carload lots, which is not the case with raw phosphate. Landowners should bear in mind the fact that phosphorus additions to the soil in amounts above the immediate crop requirements represent a permanent investment, since this element is not readily lost in the drainage water as in the case of nitrogen. It is removed from the farm thru the sale of crops, milk, and animals.

Phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

The Potassium Problem

Normal soils, in which clay and silt form a considerable part of the constituency, are well stocked with potassium, altho it exists largely in insoluble

form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be supplied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of normal soils are concerned, that the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part perhaps because the potassium removed in the crops is mostly returned in the manure if properly cared for, and perhaps in larger part because the decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no plant food of value.

In considering the conservation of potassium on the farm it should be remembered that in average live-stock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in live-stock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by the actual crop requirements for plant food, magnesium and calcium are more limited in some Illinois soils than potassium. But with these elements we must also consider the loss by leaching.

Doctor Edward Bartow and associates, of the Illinois State Water Survey, have shown that as an average of 90 analyses of Illinois well-waters drawn chiefly from glacial sands, gravels, or till, 3 million pounds of water (about the average

annual drainage per acre for Illinois) contained 11 pounds of potassium, 130 of magnesium, and 330 of calcium. These figures are very significant, and it may be stated that if the plowed soil is well supplied with the carbonates of magnesium and calcium, then a very considerable proportion of these amounts will be leached from that stratum. Thus the loss of calcium from the plowed soil of an acre at Rothamsted, England, where the soil contains plenty of limestone, has averaged more than 300 pounds a year as determined by analyzing the soil in 1865 and again in 1905. And practically the same amount of calcium was found by analyzing the Rothamsted drainage waters.

Common limestone, which is calcium carbonate ($CaCO_3$), contains, when pure, 40 percent of calcium, so that 800 pounds of limestone is equivalent to 320 pounds of calcium. Where 10 tons per acre of ground limestone was applied at Edgewood, Illinois, the average annual loss during the next ten years amounted to 790 pounds per acre. The definite data from careful investigations thus seem to indicate that where limestone is needed at least 2 tons per acre should be applied every four or five years.

It is of interest to note that thirty crops of clover of 4 tons each would require 3,510 pounds of calcium, while the most common prairie land of southern Illinois contains only 3,420 pounds of total calcium in the plowed soil of an acre. Thus limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals —to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of

sulfur, such as exists in our common types of soil, and an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply to conditions in Illinois.

Physical Improvement of Soils

In the management of most soil types, one very important thing, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is being destroyed during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, corn stalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and corn stalks should be turned under, and not burned. Probably no form of organic matter acts more beneficially in producing good tilth than corn stalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of corn stalks is one and one-half times that of a ton of manure, and a ton of dry corn stalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the corn stalks during the winter and often rather late in the spring after the frost is out of the ground. This tramping by stock sometimes puts the soil in bad condition for

working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The bad effect will be greater if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including a liberal use of legumes, in order to increase the organic matter of the soil either by plowing under the legume crops and other crop residues (straw and corn stalks), or by using for feed and bedding practically all the crops raised and returning the manure to the land with the least possible loss. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations, applicable to the corn belt, which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover), or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in live-stock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be seeded four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Wheat (with clover)
Second year —Corn
Third year —Oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields Representing the More Important Types of Soil Occurring in Adams County)

In the earlier reports of this series it was the practice to incorporate in the body of the report the results of certain experiment fields, for the purpose of illustrating the possibilities of improving the soil of various types. The information carried by such data must, naturally, be considered more or less tentative. As the fields grow older new facts develop, which in some instances may call for the modification of former recommendations. It has therefore seemed desirable to separate this experiment field data from the more permanent information of the soil survey, and embody the same in the form of a supplement to the soil report proper, thus providing a convenient arrangement for possible future revisions as additional data accumulate.

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the summarized results from certain of these fields which are representative of the types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement

These fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, live-stock farming and grain farming.

In the live-stock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in form of plant manures, including all the plant residues produced, such as corn stalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It is the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the live-stock system.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations, and on most of the fields provision is made so that every crop in the rotation is represented every year. The most common rotation used is wheat,

corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. In the event of clover failure, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, in large part, been standardized according to a rather definite system, altho many deviations from this system occur.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—All crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The usual yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, the equivalent of 200 pounds of kainit. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

BROWN SILT LOAM

Several experiment fields have been conducted on brown silt loam soil at various locations in Illinois. Those located at the University have been in operation the longest and they serve well to illustrate the principles involved in the maintenance and improvement of this type of soil.

The Morrow Plots

It happens that the oldest soil experiment field in the United States is located on typical brown silt loam of the early Wisconsin glaciation, on the campus of the University of Illinois. This field was started in 1879 by George E. Morrow, who for many years was Professor of Agriculture, and these plots are known as the Morrow plots.

The Morrow series now consists of three plots divided into halves and the halves are subdivided into quarters. On one plot corn is grown continuously; on the second, corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904, receiving standard applications of farm manure with cover crops grown in the one-crop and two-crop systems. Phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. At the same time the rate of subsequent application of both forms of phosphorus was reduced to one-fourth the quantity, or to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per year. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre with the intention of standardizing the application to the rate of 1,000 pounds of limestone per acre per year.

Table 1 gives the yearly record of the crop yields, and Table 2 presents the same in summarized form.

FIG. 1.—CORN ON THE MORROW PLOTS IN 1910

TABLE 1.—URBANA FIELD, MORROW PLOTS: BROWN SILT LOAM; PRAIRIE; EARLY WISCONSIN GLACIATION

Crop Yields in Soil Experiments—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
		Corn	Corn	Oats	Corn	Oats	Clover
1879-87	None........	....	....	....	....	....	....
1888	None........	54.3	49.5	....	....	48.6	....
1889	None........	43.2	....	37.4	....	....	(4 04)
1890	None........	48.7	54.3	....	....	....	(1.51)
1891	None........	28.6	33.2	....	....	....	(1.46)
1892	None........	33.1	....	37.2	70.2	....	....
1893	None........	21.7	29.6	....	34.1	....	....
1894	None........	34.8	....	57.2	....	65.1	....
1895	None........	42.2	41.6	....	....	22.2	....
1896	None........	62.3	....	34.5	....	....	....
1897	None........	40.1	47.0	....	....	....	....
1898	None........	18.1	....	....	....	....	....
1899	None........	50.1	44.4	....	53.5	....	....
1900	None........	48.0	....	41.5	....	....	....
1901	None........	23.7	33.7	....	34.3	....	....
1902	None........	60.2	....	56.3	....	54.6	....
1903	None........	26 0	35.9	....	....	....	(1.11)
1904	None........	21.5	....	17.5	55.3	....	....
1904	MLP........	17.1	....	25.3	72.7	....	....
1905	None........	24.8	50.0	....	....	42.3	....
1905	MLP........	31.4	44.9	....	....	50.6	....
1906	None........	27.1	....	34.7	....	....	(1.42)[1]
1906	MLP........	35.8	....	52.4	....	....	(1.74)[1]
1907	None........	29.0	47.8	....	80.5	....	....
1907	MLP........	48.7	87.6	....	93.6	....	....
1908	None........	13.4	....	32.9	....	40.0	....
1908	MLP........	28.0	....	45.0	....	44.4	....
1909	None........	26.6	33.0	....	....	....	(.65)[2]
1909	MLP........	31.6	64.8	....	....	....	(1.73)[3]
1910	None........	35.9	....	33.8	58.6	....	....
1910	MLP........	54.6	....	59.4	83.3	....	....
1911	None........	21.9	28.6	....	....	20.6	....
1911	MLP........	31.5	46.3	....	....	38.0	....
1912	None........	43.2	....	55.0	....	....	16.3[1]
1912	MLP........	64.2	....	81.0	....	....	20.0[1]
1913	None........	19.4	29.2	....	33.8	....	....
1913	MLP........	32.0	25.0	....	47.8	....	....
1914	None........	31.6	....	33.6	....	39.6	....
1914	MLP........	39.4	....	58.2	....	60.4	....
1915	None........	40.0	49.0	....	....	....	24.2[1]
1915	MLP........	66.0	81.2	....	....	....	27.1[1]
1916	None........	11.2	....	37.5	27.8	....	....
1916	MLP........	10.8	....	64.7	40.6	....	....
1917	None........	40.0	48.4	....	....	68.4	....
1917	MLP........	78.0	81.4	....	....	86.9	....
1918	None........	13.6	....	27.2	....	....	(2.58)
1918	MLP........	32.6	....	59.3	....	....	(4.04)
1919	None........	24.0	30.8	....	52.2	....	....
1919	MLP........	43.4	66.2	....	70.8	....	....
1920	None........	28.2	....	37.2	....	52.2	....
1920	MLP........	54 4	....	51.6	....	69.7	....
1921	None.......	19.8	30.6	....	....	....	(.26)[4]
1921	MLP.......	42.2	6[illegible].4	...	....	....	(1.33)[5]

[1]Soybeans.
[2]In addition to the hay, .64 bushel of seed was harvested.
[3]In addition to the hay, 1.17 bushels of seed were harvested
[4]In addition to the hay, .53 bushel of seed was harvested.
[5]In addition to the hay, .85 bushel of seed was harvested.

TABLE 2.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY
Average Annual Yields—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover
		16 crops	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
1888 to 1903	None........	39.7	41.0	44.0	48.0	47.6	(2.03)
		18 crops	*9 crops*	*9 crops*	*6 crops*	*6 crops*	*4 crops*
1904 to 1921	None........	26.2	38.6	34.4	51.4	43.9	(1.23)[1]
	MLP........	41.2	62.9	55.2	68.1	58.3	(2.21)[1]

[1]One crop of soybean hay.

Summarizing the data from these Morrow plots into two periods with the second period beginning in 1904 when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oats production, while the averages for the three-year system show an increase in corn yield and decreases in oats and clover. Unfortunately the numbers of crops included in these last averages are too small to warrant positive conclusions.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

The Davenport Plots

Another set of plots on the University campus at Urbana, forming a more extensive series than the Morrow plots, but of more recent origin, are the Davenport plots. Here each crop in the rotation is represented every year. These plots were laid out in 1895, but special soil treatment was not begun until 1901. They now comprize five series of ten plots each, and each series constitutes a "field" in a crop rotation system.

From 1901 to 1911 three of the series were in a three-year rotation system of corn, oats, and clover, while the remaining two series rotated in corn and oats. In 1911 these two systems were combined into a five-series field, with a crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field. The alfalfa occupies one series during a rotation of the other four crops, shifting to another series in the fifth year, thus completing the cycle of all series in twenty-five years.

The soil treatment applied to these plots has been as follows:

Legume cover crops were seeded in the corn at the last cultivation on Plots 2, 4, 6, and 8, from 1902 to 1907, but the growth was small and the effect, if any, was to decrease the returns from the regular crops. Crop residues (**R**) have been returned to these same plots since 1907. These consist of stalks and straw, and all legumes except alfalfa hay and the seed of clover and soybeans. Beginning in 1918 a modification of the practice was made in that one cutting of the red clover crop is harvested as hay. In conjunction with these residues a catch crop of sweet clover grown with the wheat is plowed under.

Manure (**M**) was applied preceding corn, at the rate of 2 tons per acre per year in 1905, 1906, and 1907; subsequently as many tons have been applied as there have been tons of air-dry produce harvested from the respective plots.

Lime (**L**) was applied on Plots 4 to 10 at the rate per acre of 250 pounds of air-slaked lime in 1902, and 600 pounds of limestone in 1903. No further application was made until 1911, when the system of cropping was changed. Since that time applications of limestone have been made at the rate of one-half ton per acre per year.

Phosphorus (**P**) was applied on Plots 6 to 9 at the rate of 25 pounds per acre per annum in 200 pounds of steamed bone meal; but beginning with 1908 rock phosphate at the rate of 600 pounds per acre per annum was substituted for the bone meal on the west half of each of these plots. These applications continued until 1918 when adjustments were begun, first to make the rate of application of rock phosphate four times that of the bone meal, and finally to reduce the amounts of these materials to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per annum. The usual practice has been to apply and plow under at one time all phosphorus and potassium required for the rotation.

Potassium (**K** = kalium) has been applied on Plots 8 and 9, in connection with the organic manures and phosphorus, at the yearly rate of 42 pounds per acre, and mainly as potassium sulfate.

On Plot 10 about five times as much manure and phosphorus are applied as on the other plots, but this ''extra heavy'' treatment was not begun until 1906, only the usual amounts of lime, phosphorus, and potassium having been applied in previous years. The purpose in making these heavy applications is to try to determine the climatic possibilities in crop yields by removing the limitations of inadequate fertility.

It will be observed that the applications mentioned above provide for the two rather distinct systems of farming already described. *The grain system,* in which animal manure is not produced and where the organic matter is provided by the direct return to the soil of all crop residues along with legumes, is exemplified in Plots 2, 4, 6, and 8; and the *live-stock system,* in which farm manure is utilized for soil enrichment, is represented in Plots 3, 5, 7, and 9.

Table 3 shows a summary of the results obtained on the Davenport plots beginning with the year 1911, when the present cropping system was introduced.

When used in conjunction with phosphorus the crop residues and the manure appear about equally effective; but where phosphorus is not applied, the manure has been decidedly more effective, under the conditions of the experiment. It should be observed, however, in this connection, that the plowing under of clover is a very essential feature of the residues system, and that, as a matter of fact, there were five clover failures, when soybeans were substituted, during the ten years. Perhaps with a more reliable biennial legume than red clover, the results would have been more favorable for this system.

By comparing Plots 2 and 3 with Plots 4 and 5, it is found that limestone has had a beneficial effect on all crops. What the financial profit amounts to depends obviously upon the market value of the crops and the cost of the limestone.

TABLE 3.—URBANA FIELD, DAVENPORT PLOTS: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION
Average Annual Yields—Bushels or (tons) per acre
1911–1920

Serial plot No.	Soil treatment applied	Corn	Oats	Wheat	Clover 5 crops	Soybeans 5 crops	Alfalfa
1	0.............	55.6	50.5	26.0	(2.42)	(1.47)	(2.43)
2	R.............	57.1	52.3	28.7	1.47[1]	19.8	(2.46)
3	M.............	66.3	61.9	28.2	(2.56)	(1.62)	(2.52)
4	RL............	64.8	55.6	31.4	1.61[1]	20.3	(2.72)
5	ML............	69.6	64.1	32.8	(2.90)	(1.67)	(3.03)
6	RLP...........	71.5	69.8	43.0	2.29[1]	23.5	(3.69)
7	MLP...........	73.0	68.6	40.0	(3.52)	(1.97)	(3.76)
8	RLPK..........	70.9	72.5	40.7	1.79[1]	25.5	(3.77)
9	MLPK..........	70.2	72.0	39.2	(3.40)	(2.20)	(3.73)
10	Mx5LPx5.......	65.9	71.4	40.6	(3.31)	(2.22)	(3.77)

[1]In addition to the clover seed, a crop of hay was harvested one year on Plots 2, 4, 6, and 8, yielding 2.38, 2.20, 2.54, and 2.39 tons respectively.

Comparing Plots 4 and 5 with Plots 6 and 7, respectively, there is found in all cases an increase in crop yield as a result of adding phosphorus. The effect on wheat is especially pronounced. Where limestone and phosphorus are applied in addition to the crop residues, an increase of 17 bushels of wheat, over the yield of the untreated land, has been obtained as a ten-year average.

Manure
Yield: 1.43 tons per acre

Manure, limestone, phosphorus
Yield: 2.90 tons per acre

FIG. 2.—CLOVER ON THE DAVENPORT PLOTS IN 1913

The effect of adding potassium to the treatment is of much interest. Plots 8 and 9 are the same as Plots 6 and 7, respectively, except that potassium has been applied to the former. On the whole, no significant benefit is shown from the addition of potassium.

No benefit appears as the result of the extra-heavy applications of manure and phosphorus on Plot 10. In fact the corn yields are noticeably less here than on the plots receiving the normal applications of these materials.

The University South Farm

On the University South Farm, at Urbana, several series of plots devoted primarily to variety testing and other crop-production experiments are so laid out as to show the effects of certain soil treatments that have been applied. Several different systems of crop rotation are employed and the crops are so handled as to exemplify the two general systems of farming, grain and live-stock.

The summarized results presented in Table 4 represent three different systems of cropping. The first, designated as the Southwest rotation, is to be regarded as a good rotation for general practice, on this type of soil, under Illinois conditions. This is a four-field rotation of wheat, corn, oats, and clover.

TABLE 4.—URBANA FIELD, SOUTH FARM: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre
1908-1919

Southwest Rotation: Series 100, 200, 400[1]: Wheat, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 9 crops	Oats[3] 9 crops	Wheat[3] 8 crops	Clover[4] 3 crops	Soybeans 7 crops
RP	62.3	51.9	41.0	1.05	17.3[5]
R	51.9	46.5	26.9	1.38	16.2[5]
M	59.7	50.2	29.1	(2.28)	(1.25)
MP	64.3	55.4	43.1	(2.86)	(1.51)
RLP	60.5	57.2	41.8	.64	16.4[5]
R	49.7	49.6	25.8	.83	14.7[5]
M	55.5	54.1	27.8	(1.71)	(1.28)
MLP	64.1	59.6	43.9	(1.77)	(1.58)

North-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Oats 9 crops	Clover 5 crops	Soybeans 4 crops
RP	56.7	51.1	56.1	.54	16.9
R	51.7	45.2	52.0	.50	16.0
M	54.9	46.7	52.1	(2.29)	(1.60)
MP	56.5	53.4	56.9	(2.73)	(1.74)

South-Central Rotation: Series 500, 600, 700[1]: Corn Corn, Corn, Soybeans

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Corn 3d year 9 crops		Soybeans 9 crops
RP	51.9	44.0	41.3		20.0
R	45.5	39.9	35.2		19.2
M	50.1	42.1	33.5		(1.59)
MP	54.5	46.7	42.0		(1.66)

[1]Results from Series 300 and 800 are omitted on account of variation in soil type.
[2]Soybeans when clover fails.
[3]Only seven crops with limestone.
[4]Only one crop with limestone.
[5]Average of five crops.
[6]All phosphorus plots received ½ ton per acre of limestone in 1903.

TABLE 5.—COMPARING PRODUCTION OF CORN IN THREE DIFFERENT ROTATION SYSTEMS YIELDS FROM PLOTS ON THE UNIVERSITY SOUTH FARM

Twelve-Year Average (1908–1919)—Bushels per acre

Rotation	Wheat-corn-oats-legume[1]	Corn-corn-oats-legume[2]		Corn-corn-corn-legume[3]		
Treatment	Corn	1st Corn	2d Corn	1st Corn	2d Corn	3d Corn
Organic manures..............	55.8	53.3	46.0	47.8	41.0	34.3
Organic manures, phosphorus...	63.2	56.6	52.3	53.2	45.3	41.6

[1]Clover 3 crops and soybeans 7 crops.
[2]Clover 5 crops, and soybeans 5 crops.
[3]Soybeans 9 crops.

The second, or North-Central rotation, consisting of corn, corn, oats, and clover, represents a system very commonly practiced; and the third or South-Central rotation, consisting of corn, corn, corn, and soybeans, must be considered as a poor rotation from the standpoint of maintaining the productiveness of the land.

On the whole, the "residues" have not returned yields quite so high as those produced by the manure treatment; but, as remarked above in the discussion of the Davenport plots, the residues system has probably been at a disadvantage thru frequent clover failures. On the North-Central rotation, where conditions seem to have been more favorable for clover, there is very little difference between the effect of manure and of residues.

Residues plowed under
Yield: 35.2 bushels per acre

Residues and rock phosphate
Yield: 50.1 bushels per acre

FIG. 3.—WHEAT ON THE UNIVERSITY SOUTH FARM IN 1911

In the rotation system in which limestone is being applied, no benefit of consequence to any of the crops except oats appears from the use of this material. The test, however, has hardly been of sufficient duration to warrant final conclusions; and furthermore, the comparison may be somewhat impaired by a possible residual effect of the small application of limestone made in 1903 to all the phosphorus plots.

The results obtained from the use of phosphorus are important because this element has been applied to these plots solely in the form of raw rock phosphate. The figures in almost every case show an increase in yield where the phosphorus has been applied, and in most cases this increase is very pronounced. The wheat is especially responsive to phosphorus.

The records furnish some interesting comparisons of corn yields produced under different systems of cropping. Table 5 gives a general summary of the corn yields only, in which the results from the residues and manure treatments are averaged together as "organic manures." The highest annual acre-yields are found where corn occurs but once in a rotation. Where corn is grown twice in succession, the annual acre-yields are less; and where corn occurs three times, there is a further reduction. Also, the first crop of corn within a rotation produces more than the second, and the second crop yields more than the third. These are useful facts for consideration in connection with problems of general farm management.

The Clayton Field

An experiment field representing a light phase of the brown silt loam is located in Adams county just south of Clayton. This field has been in operation since 1911. The diagram presented as Fig. 4 shows the arrangement of the plots on this field.

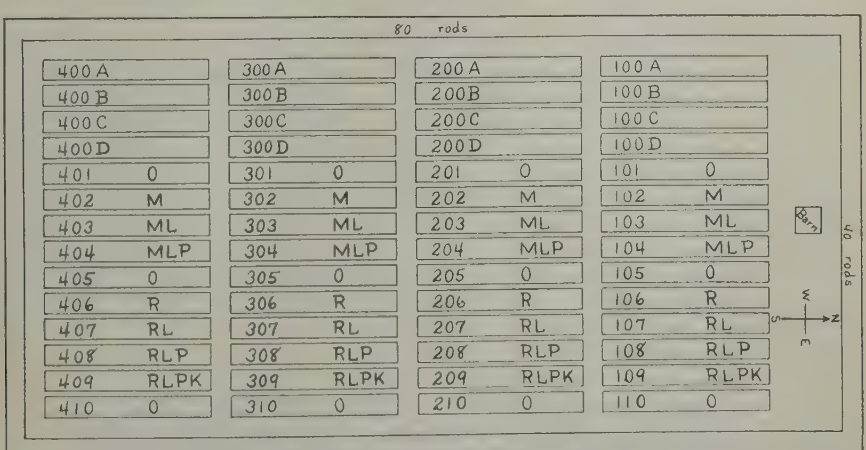

FIG. 4.—DIAGRAM SHOWING ARRANGEMENT OF PLOTS ON THE CLAYTON EXPERIMENT FIELD

TABLE 6.—CLAYTON FIELD: BROWN SILT LOAM, PRAIRIE; UPPER ILLINOISAN GLACIATION
ROTATION: WHEAT, CORN, OATS, CLOVER

Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1911 Corn[1]	1912 Oats[2]	1913 Soybeans[5]	1914 Wheat[6]	1915 Corn	1916 Oats	1917 Clover	1918 Wheat	1919 Corn	1920 Oats	1921 Soybeans
101	0.......	45.8	43.0	10.3	5.0	23.3	19.2	(2.01)	27.3	37.7	22.3	20.1
102	M......	50.0	42.3	(1.49)	4.8	27.3	21.6	(2.51)	30.2	50.3	38.1	18.8
103	ML.....	52.4	39.3	(1.58)	5.3	28.6	20.8	(3.26)	42.8	47.9	32.8	28.1
104	MLP....	48.7	46.9	(1.50)	5.4	31.5	23.0	(3.55)	47.0	41.6	40.6	21.5
105	0.......	54.6	44.1	12.1	6.2	25.6	20.3	1.92	33.3	30.1	25.9	21.3
106	R.......	56.5	40.0	12.5	8.5	36.0	20.2	2.17	33.7	49.7	43.1	25.8
107	RL......	57.6	41.6	13.5	6.8	55.4	31.4	2.17	45.5	57.9	52.8	24.3
108	RLP....	55.5	42.3	13.0	8.8	55.2	38.6	2.00	50.8	59.0	55.5	20.3
109	RLPK...	52.0	43.8	11.8	7.9	56.5	35.9	2.00	47.6	70.7	51.9	25.5
110	0.......	54.0	50.0	12.7	7.5	27.3	25.9	(2.94)	31.2	49.3	46.1	17.5
		Oats[1]	Corn[3]	Oats	Soybeans	Wheat	Corn	Oats	Clover	Wheat	Corn	Oats
201	0.......	19.5	35.4	45.5	(1.28)	11.2	17.1	63.8	(2.74)	21.7	44.3	28.4
202	M......	19.1	47.4	55.3	(1.41)	17.9	21.4	71.6	(2.79)	18.9	66.4	45.2
203	ML.....	16.9	36.9	51.6	(1.38)	14.5	21.5	70.6	(2.78)	19.0	75.1	42.2
204	MLP....	20.9	56.8	56.1	(1.45)	23.2	21.0	72.3	(2.61)	18.6	76.7	39.2
205	0.......	18.9	38.7	45.9	14.2	7.0	15.2	65.9	(2.06) 1.00	20.3	53.2	31.2
206	R.......	18.1	52.1	45.9	16.7	16.2	26.7	69.8	(2.18) .83	19.8	59.2	32.0
207	RL......	18.9	50.5	48.3	18.3	16.1	26.8	82.8	(2.18) .58	19.3	65.7	34.2
208	RLP....	20.9	54.4	52.2	19.6	30.2	26.9	77.5	(2.54) .58	20.0	70.1	39.8
209	RLPK...	17.5	55.5	47.7	17.1	29.2	24.6	83.6	(2.29) .42	21.2	71.6	41.9
210	0.......	25.0	36.2	45.5	(1.40)[7]	14.8	15.1	65.9	(2.60)	20.3	46.1	30.6

TABLE 6.—CLAYTON FIELD, *Concluded*

		1911 Soy-beans[1]	1912 Barley[4]	1913 Corn	1914 Oats	1915 Soy-beans	1916 Wheat	1917 Corn	1918 Oats	1919 Soy-beans	1920 Wheat	1921 Corn
301	0.......	12.0	19.6	35.4	10.0	(2.52)	1.6	30.4	38.6	(1.55)	16.4	30.1
302	M.......	12.5	19.7	55.2	14.7	(2.58)	2.0	52.8	49.2	(1.66)	30.8	52.3
303	ML.....	13.0	20.2	55.1	13.3	(2.83)	3.9	61.2	50.6	(1.86)	27.5	67.9
304	MLP....	12.8	22.6	58.4	15.9	(3.11)	4.6	60.5	53.9	(1.62)	32.8	67.7
305	0.......	14.6	21.5	42.1	13.9	12.5	1.8	35.2	37.5	23.1	11.0	42.3
306	R.......	14.4	21.4	49.7	17.3	12.5	4.4	52.6	46.9	20.8	11.5	58.4
307	RL......	14.8	22.2	52.2	16.6	19.2	5.6	59.9	57.0	23.5	19.6	65.0
308	RLP....	14.8	24.5	55.1	18.4	19.6	7.5	65.6	73.4	25.0	21.9	66.0
309	RLPK...	14.8	30.8	52.6	16.9	22.5	9.0	64.0	69.7	27.5	22.7	73.3
310	0.......	13.8	18.9	43.6	14.7	(2.21)	1.7	20.3	35.3	(1.38)	19.2	43.9
		Oats[1]	Soy-beans[2]	Wheat[6]	Corn	Oats	Clover	Wheat	Corn	Oats	Clover	Wheat
401	0.......	27.0	16.4	32.9	36.0	58.1	(2.30)	18.0	20.2	42.5	(1.70)	21.4
402	M.......	32.2	(1.36)	31.0	37.8	61.6	(2.77)	21.7	49.8	50.3	(2.44)	29.1
403	ML.....	30.0	(1.36)	31.6	48.7	64.5	(2.76)	21.6	57.1	51.4	(2.64)	32.0
404	MLP....	30.8	(1.36)	34.0	46.1	69.5	(2.51)	23.5	50.4	49.5	(2.53)	32.1
405	0.......	32.8	17.5	34.1	29.9	60.5	1.83	20.4	22.1	45.0	(1.40) .96	22.6
406	R.......	33.3	16.7	33.3	30.4	50.5	1.58	26.7	33.7	46.7	(1.64) .83	24.1
407	RL......	33.3	16.9	33.8	41.6	62.5	1.00	21.5	44.6	43.0	(2.92) .80	29.1
408	RLP....	39.3	17.2	37.0	31.9	68.0	1.00	23.2	42.5	48.0	(2.55) 1.71	31.4
409	RLPK...	34.7	16.3	37.3	45.5	65.6	1.25	24.7	51.5	51.9	(3.10) .96	30.2
410	0.......	35.6	17.5	35.0	34.8	62.2	(2.15)	16.0	24.4	47.8	(1.98)	22.3

[1]No treatment. [2]Residues only. [3]No lime. [4]No manure or lime. [5]No manure, phosphate or potassium. [6]No manure. [7]Estimated.

There are four series of plots, the series numbering by hundreds from north to south. Each series has fourteen plots numbering in order from west to east and separated by half-rod division strips. Plots A, B, C, and D have only recently been added to the regular series, and no results are reported for these plots at this time.

The crop rotation practiced on this field is wheat, corn, oats, and clover. Soybeans have several times been substituted for the clover. The yields of all the crops grown each year since the beginning of the experiments are presented in Table 6. These results are summarized in Table 7, which shows the average yields of the respective crops for each treatment covering the years that full treatment has been under way. The lower section of this table gives a more condensed summary which affords some interesting comparisons. Here the results from the corresponding plots of the live-stock and grain systems are so combined as to bring out the effect of organic manures alone, organic manures in combination with limestone, and organic manures in combination with limestone and phosphorus.

TABLE 7.—CLAYTON FIELD: GENERAL SUMMARY
Average Annual Yields—Bushels or (tons) per acre 1913-1921

Serial plot No.	Soil treatment applied	Wheat 7 crops	Corn 9 crops	Oats 9 crops	Legumes[1] 8 crops
1	0	16.8	30.5	36.5	(2.01)
2	M	21.5	45.9	45.3	(2.26)
3	ML	23.0	51.5	44.2	(2.54)
4	MLP	26.0	50.4	46.7	(2.44)
5	0	16.6	33.0	38.5	(2.04)
6	R	19.5	44.0	41.4	(2.10)
7	RL	22.4	52.1	47.6	(2.27)
8	RLP	26.4	52.5	52.4	(2.35)
9	RLPK	26.4	56.7	51.7	(2.41)
10	0	17.9	33.9	41.6	(2.05)
4, 8	M, R } LP	26.2	51.5	49.6	(2.40)
3, 7	M, R } L	22.7	51.8	45.9	(2.41)
2, 6	M, R	20.5	45.0	43.4	(2.18)
1, 5, 10	0	17.1	32.5	38.9	(2.03)

[1]These figures represent the average combined yields of clover and soybeans, whether hay or seed, expressed as the equivalent of clover hay.

In looking over these results, attention is called first to the beneficial effect of organic manures, whether they have been applied in the form of animal manure or as plant manures (crop residues and legumes turned under). This improvement obtained by adding organic matter indicates the importance of carefully conserving and regularly applying all available farm manure. If farm manure is not available in sufficient quantity, then, as these results demonstrate, the necessary organic matter can be supplied by returning to the land all unused crop residues and by plowing under legume crops.

The results also bring out the beneficial effect of limestone on this soil, all crops showing in the general averages increases in yield where this material has been applied.

The use of raw rock phosphate applied along with organic manures and limestone has produced still further increases for wheat and oats, but not for corn. Potassium salts appear to have benefited the corn, but not the wheat and oats, altho the increase in corn yield would not pay for the cost of the treatment.

On the whole, the results of the Clayton field are in accord with what has been found to be generally true of the brown silt loam type of soil. For the establishment of a permanent system of fertility, organic matter and phosphorus are needed, and where limestone is lacking this material should be applied. Where organic manures, limestone, and phosphate have been applied on the Clayton field, the yield of wheat has averaged 26.2 bushels per acre as compared with 17.1 bushels on the check plots, an increase amounting to ½ of the crop that was produced without treatment; the yield of corn has averaged 51.5 bushels as compared with 32.5 bushels, also an increase of more than 50 percent; the yield of oats has averaged 49.6 bushels as compared with 38.9 bushels, representing about a 25 percent increase; the yield of hay, or its equivalent (the value of seed crops produced being expressed as the equivalent to tons of hay), has averaged 2.40 tons per acre as compared with 2.03 tons, an increase of about ⅙ of the untreated crop.

YELLOW-GRAY SILT LOAM

Yellow-gray silt loam exhibits an important variation with respect to limestone content. In some areas, altho limestone may be altogether absent in the surface stratum it is found in abundance at a short distance beneath the surface. Accordingly, variations in response to soil treatment are exhibited by different experiment fields located on this type. In view of this discrepancy it is thought well to introduce here the records of two fields, that are representative of the type but which show a marked diversity in results, one in northern Illinois and one in the southern part of the state.

The Antioch field is located on the late Wisconsin glaciation, in Lake county, close to the Wisconsin border. The field was started in 1902, with but a single series of ten plots, under a rotation of corn, corn, oats, and wheat; but beginning with 1911 the rotation has been wheat, corn, oats, and clover. It was started in order to learn as quickly as possible what effect would be produced by the addition to this type of soil of nitrogen, phosphorus, and potassium, used singly and in combination. Therefore these elements were all applied in commercial form until 1911, after which the use of commercial nitrogen was discontinued and crop residues were substituted in its place. Nitrogen was supplied in the earlier years in 800 pounds of dried blood per acre. Phosphorus is applied in 200 pounds of steamed bone meal, and potassium in 100 pounds of potassium sulfate. At the beginning, 470 pounds of slaked lime was applied; but since 1912 limestone has been applied at the rate of 1,000 pounds per acre per year.

Table 8 presents, in summarized form, the results from the Antioch field. Because of an abnormality in Plot 1, the results from this plot are not considered. The data show that phosphorus is the one element standing out prominently as producing consistently beneficial results. Potassium applied in addition to phosphorus has, on the whole, not produced profitable results. Also, the

TABLE 8.—ANTIOCH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LATE WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre
1902-1921

Serial plot No.	Soil treatment applied	Corn 8 crops	Oats 5 crops	Wheat 4 crops	Clover[1] 3 crops
1	0	23.9	32.3	15.8	1.33
2	L	21.3	26.8	13.2	1.26
3	LR	21.3	29.9	20.6	1.45
4	LP	30.7	43.6	36.7	1.61
5	LK	23.7	27.8	19.2	1.21
6	LRP	33.8	43.3	33.3	1.13
7	LRK	24.3	26.9	20.8	1.22
8	LPK	25.1	38.2	30.9	1.51
9	LRPK	38.3	42.6	28.0	1.00
10	RPK	38.4	44.7	30.2	1.28

[1] These figures represent the average combined yields of hay and seed, expressed as the equivalent of clover hay.

Lime applied and residues plowed under

Lime and phosphorus applied

FIG. 5.—CLOVER IN 1913 ON ANTIOCH FIELD

results are unfavorable for the application of limestone. Limestone, however, is abundant in the subsoil of this type in the region of this field.

The Raleigh experiment field is located on the lower Illinoisan glaciation, in southern Illinois, in Saline county. This field is laid out into four series of ten plots each, under a rotation of wheat, corn, oats, and clover. The treatments, along with the summarized results, are given in Table 9.

The outstanding feature of these results is the effect of limestone. Altho manure alone produces a substantial increase, especially in the corn crop, when

Manure, limestone, phosphorous
Yield: 61 bushels per acre

Nothing applied
Yield: 15 bushels per acre

FIG. 6.—CORN ON RALEIGH FIELD IN 1920

TABLE 9.—RALEIGH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LOWER ILLINOISAN GLACIATION

Average Annual Yields—Bushels or (tons) per acre
1911-1921

Serial plot No.	Soil treatment applied	Corn 11 crops	Oats 11 crops	Wheat 7 crops	Legumes[1] 9 crops
1	0	15.8	10.2	6.2	(.42)
2	M	27.6	12.5	7.9	(.55)
3	ML	39.0	19.6	21.7	(1.14)
4	MLP	40.0	19.8	22.5	(1.36)
5	0	16.4	10.0	7.3	(.14)
6	R	19.4	12.8	8.8	(.19)
7	RL	34.3	21.2	19.7	(.71)
8	RLP	36.7	22.4	22.4	(.81)
9	RLPK	42.7	23.0	23.8	(.81)
10	0	20.2	11.2	6.9	(.30)

[1] These figures represent the average combined yields of clover and soybeans, whether hay or seed, expressed as the equivalnt of clover hay.

limestone is added a remarkable increase is found in all crops. A most important fact is that the organic matter can be effectively built up thru the use of crop residues, with the application of limestone, so that the crop yields are practically as high under this "grain system" of farming as where manure is used.

Phosphorus thus far has given only moderate returns in increased crop yields, but with an increasing quantity of organic matter and nitrogen it is probable that the phosphorus applications will show up more favorably on subsequent crops. As to the use of potassium, it is to be noted that aside from an

increase of 6 bushels of corn in the residues system, the beneficial effect has not been sufficient to justify the use of this material.

In accounting for the discrepancy in the response to limestone on these two fields, the fact is to be considered that the Antioch field is located on the late Wisconsin glaciation, where the subsoil contains large quantities of limestone; while the Raleigh field represents the lower Illinoisan glaciation, the soil of which is very acid to a great depth.

In view of these variations, a general recommendation for a complete treatment for soil of this type, that will apply to all localities, cannot be given out until more information is acquired.

Fortunately, however, each farmer can determine for himself the need of limestone for his land by applying the simple tests for the presence of carbonates and soil acidity, as explained under the discussion of limestone on pages 36 and 37 of the Appendix.

Phosphorus, which has paid well on the Antioch field, and has given doubtful returns thus far at Raleigh, has varied considerably in its effect when used on other fields located on this same type of soil. In this situation, therefore, the present suggestion would be that each farmer might well try out phosphorus on his own land, on a limited scale, and be guided by the outcome of his experience. The low phosphorus content of the surface stratum of this soil is an indication that in a system of permanent agriculture the time is not far off when phosphorus will become a limiting element to crop production, and the wise farmer will watch carefully the indications and be ready to make timely provision for this need.

YELLOW SILT LOAM

Because such a large proportion of the area of Adams county is made up of yellow silt loam it is thought that an account of some experiments on the Vienna field, the single representative of this type of soil, would be of interest here.

The Vienna Field

In 1906 the University acquired a sixteen-acre tract of land representative of yellow silt loam near Vienna in Johnson county. The whole area with the exception of about three acres had been abandoned because so much of the surface soil had washed away and there were so many gullies as to render further cultivation of this land unprofitable. Experiments were started at once to reclaim this land, the different methods described below being used for this purpose.

The field was divided into five sections. The sections designated as A, B, and C were divided into four plots each, and D into three plots. On section A, which included the steepest part of the area and contained many gullies, the land was built up into terraces at vertical intervals of five feet. Near the edge of each terrace a small ditch was placed so that the water could be carried to a natural outlet without doing much washing.

On section B the so-called embankment method was used. By this method erosion is prevented by plowing up ridges sufficiently high so that on the occasion of a heavy rainfall if the water breaks over it will run over in a broad

FIG. 7.—CORN CROP ON THE VIENNA EXPERIMENT FIELD GROWING ON IMPROVED HILLSIDE LAND THAT HAD BEEN FORMERLY BADLY ERODED. COMPARE WITH FIG. 8

sheet rather than in narrow channels. At the steepest part of the slope, hillside ditches were made for carrying away the run-off.

Section C was washed badly but contained only small gullies. Here the attempt was made to prevent washing by incorporating organic matter in the soil and practicing deep contour plowing and contour planting. With two exceptions, each year about eight loads of manure per acre were turned under for the corn crop.

The land on section D was washed to about the same extent as that of section C. As a check on the different methods of reducing erosion, the land on section D was farmed in the most convenient way, without any special effort being made to prevent washing.

FIG. 8.—VIEW OF UNIMPROVED HILLSIDE LAND TAKEN JUST OVER THE FENCE FROM THE FIELD SHOWN IN FIG. 7

Section E was badly eroded and gullied and no attempt was made to crop it other than to fill in the gullies with brush and to seed the land to grass.

Sections A, B, C, and D were not entirely uniform; some parts were washed more than others and portions of the lower-lying land had been affected by soil material washed down from above. When the field was secured, the higher land had a very low producing capacity. On many spots little or nothing would grow.

Limestone was applied to the entire field at the rate of 2 tons per acre. Corn, cowpeas, wheat, and clover were grown in a four-year rotation on each section except D which had but three plots.

Table 10 contains a summarized statement of the results obtained.

TABLE 10.—VIENNA FIELD: METHODS OF HANDLING HILLSIDE LAND TO PREVENT EROSION

Average Annual Yields—Bushels or (tons) per acre
1907-1915

Section	Method	Corn 7 crops	Wheat 7 crops	Clover 3 crops
A	Terrace	31.4	9.0	(0.68)
B	Embankments and hillside ditches	32.4	12.7	(0.97)
C	Organic matter, deep contour plowing, and contour planting	27.9	11.7	(0.80)
D	Check	14.1	4.6	(0.21)

These results indicate something of the possibilities in improving hillside land by protecting it from erosion. The average yield of corn from the protected series (A, B, and C) was 30.6 bushels per acre, as against 14.1 bushels for series D; wheat yielded 11.1 bushels in comparison with 4.6 bushels; and clover .82 ton in comparison with .21 ton.

A comparison of Figs. 7 and 8 will serve to indicate the possibility of improving this type of soil.

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 25

LIVINGSTON COUNTY SOILS

By J. G. MOSIER, S. V. HOLT, F. A. FISHER, E. E. DE TURK,
AND H. J. SNIDER

PREPARED FOR PUBLICATION BY L. H. SMITH

URBANA, ILLINOIS, JUNE, 1923

IN RECOGNITION

The Soil Survey of Illinois was organized under the supervision of the late Dr. Cyril G. Hopkins. The work progressed for eighteen years under his guidance and the first eighteen soil reports bear his name as senior author. On October 6, 1919, Dr. Hopkins died in a foreign land in the service of the American Red Cross. It is the purpose to carry on to completion this great work of the Illinois Soil Survey in the spirit, and along the same general plan and lines of procedure, in which it was begun.

INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or land owner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and land owner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

CONTENTS OF SOIL REPORT No. 25

LIVINGSTON COUNTY SOILS

APPENDIX

SUPPLEMENT

LIVINGSTON COUNTY SOILS

By J. G. MOSIER, S. V. HOLT, F. A. FISHER, E. E. DE TURK, AND H. J. SNIDER
PREPARED FOR PUBLICATION BY L. H. SMITH[1]

LOCATION AND CLIMATE OF LIVINGSTON COUNTY

Livingston county is located in the northeast quarter of Illinois. Its north boundary lies 102 miles south of the Wisconsin state line, and its east boundary 39 miles west of the Indiana line. The county is made up of 28½ townships, embracing an area of a little more than 1,000 square miles. It lies entirely within the geological area known as the early Wisconsin glaciation. Practically all the land is tillable and over 90 percent of the soil is of prairie formation.

The climate of Livingston county is characterized by a wide range between the extremes of winter and summer. The greatest range of any year from 1887 to 1920 was 136 degrees, in 1887. The lowest temperature recorded was –26°; the highest, 110°. The average date of the last killing frost in spring is May 1; the earliest in fall, October 13. The length of the growing season therefore is about 164 days.

The average annual precipitation for the county from 1887 to 1920 was 32.18 inches. The average rainfall by months for this period was as follows: January, 2.22 inches; February, 1.73; March, 2.64; April, 3.28; May, 3.85; June, 3.34; July, 2.88; August, 2.82; September, 3.36; October, 2.11; November, 2.14; December, 1.81. The proportion of total rainfall occurring during each season was: winter, 17.9 percent; spring, 30.4 percent; summer, 28.1 percent; autumn, 23.6 percent.

AGRICULTURAL PRODUCTION

Livingston county is to be regarded as distinctly agricultural, with almost the entire county tillable land. In 1920, as shown by the Fourteenth Census of the United States, there were 3,726 farms, these farms having an average of 170.9 acres each, 165.5 acres of which were improved. Of these farms, 65.6 percent were operated by tenants, which was a decrease in tenantry of 6.5 percent in ten years and 14.4 percent in the last twenty years. According to this report, the average value of land is $312.79 per acre, it ranking among the first five counties of the state in this respect.

The principal crops are corn, oats, wheat, pasture, hay, and clover. Small amounts of rye, barley, and potatoes are grown. The Census reports the following as the acreage and yield of the more important crops. It must be remembered that these figures are for but a single year—that of 1919.

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[1]J. G. Mosier, in charge of soil survey mapping (Professor Mosier died November 10, 1922, after partially preparing this report); S. V. Holt and F. A. Fisher, in charge of field party; E. E. De Turk, in charge of soil analysis; H. J. Snider, in charge of experiment fields; L. H. Smith, in charge of publications.

Crops	*Acreage*	*Production*
Corn	258,890	10,079,598 bu.
Oats	206,029	6,492,160 bu.
Wheat	25,084	422,657 bu.
Timothy	6,108	6,198 tons
Timothy and clover mixed	7,187	8,676 tons
Clover alone	10,015	11,349 tons
Alfalfa	1,505	3,592 tons
Silage crops	2,411	19,264 tons
Corn for forage	1,696	3,760 tons

The acreage of pasture is not given by the Census, but from other dat it is found to be approximately 100,000. Within the past few years the soy bean has been introduced, and this crop is gradually becoming established a one of the staple crops of the region. Likewise, the great value of swee clover has recently become recognized, and it is rapidly taking its plac among the more important crops of the county.

The live-stock interests, including those of the dairy, are of considerabl importance, as is shown by the following data, also taken from the Censu of 1920.

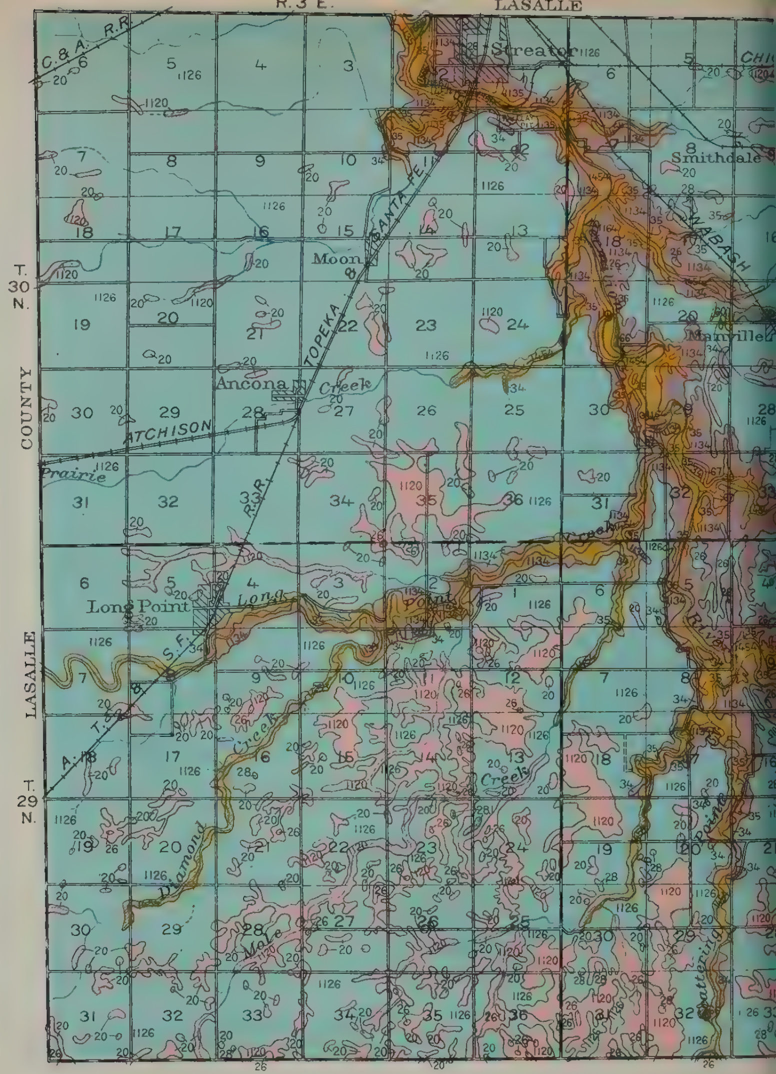
Animals and animal products	*Number*	*Value*
Horses	30,196	$3,195,405
Mules	1,870	237,229
Beef cattle	13,655	991,359
Dairy cattle	26,946	1,703,367
Sheep	7,115	95,418
Swine	53,542	1,165,914
Poultry	466,533	470,628
Eggs and chickens	.....	1,120,361
Dairy products	.....	808,347

The report gives the total value of the live stock as more than 10½ mi lion dollars.

Fruit growing is of very little importance in this county. About 32,00 quarts of small fruits were produced in 1919. The total production of apple pears, peaches, and cherries amounted to about 4,800 bushels, and the tota crop of grapes was approximately 91,000 pounds.

SOIL FORMATION

The most important period in the geological history of the county from th standpoint of soil formation was the Glacial period, during which the materia that later formed the soils was being deposited. At that time, snow and ic accumulated in the region of Labrador and to the west of Hudson Bay to suc an amount that the mass pushed outward from these centers, chiefly sout ward, until a point was reached where the ice melted as rapidly as it advance In moving across the country from the far north, the ice gathered up all sor and sizes of material, including clay, silt, sand, gravel, boulders, and eve immense masses of rock. Some of these materials were carried for hundre of miles and rubbed against surface rocks and against each other until largel ground into powder. When, thru the melting of the ice, the limit of advanc was reached, the material carried by the glacier accumulated in a broa undulating ridge or moraine. When the ice melted more rapidly than th



900 Early Wisconsin Moraines

1100 Early Wisconsin Intermorainal Areas

(a) UPLAND PRAIRIE SOILS

26 Brown silt loam

20 Black clay loam

60 Brown sandy loam

28.1 Brown silt loam on tight clay

1120.2 Gravelly black clay loam

28 Brown-gray silt loam on tight clay

26.4 / 1126.4 Brown silt loam on gravel

1126.5 Brown silt loam on rock

(b) UPLAND TIMBER SOILS

34 Yellow-gray silt loam

35 Yellow silt loam

964 / 1164 Yellow-gray sandy loam

(c) 1500 TERRACE SOILS

27 / 1527 Brown silt loam over gravel

66 / 1566 Brown sandy loam over gravel

SOIL SURVEY MAP

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Black clay loam

Yellow-gray silt loam over gravel

Brown silt loam on gravel

Black sandy loam

Yellow-gray sandy loam over gravel

Brown-gray silt loam on tight clay

Brown-gray sandy loam on tight clay

(d) 1400 LATE SWAMP AND BOTTOM-LAND SOILS

1450 Mixed loam

1426 Deep brown silt loam

1401 Deep peat

1402 Medium peat on clay

1413.6 Muck on marl

(e) 000 RESIDUAL SOIL

098 Stony loam

Scale

0 ¼ ½ 1 2 Miles

IVINGSTON COUNTY

TURAL EXPERIMENT STATION

glacier advanced, the terminus of the glacier would recede and the material would be deposited somewhat irregularly over the area previously covered.

During the Glacial period at least six distinct ice advances occurred that were separated by long periods of time. They are described as follows, in the order of their occurrence:

(1) The Nebraskan, which did not touch Illinois; (2) the Kansan, which covered the western parts of Hancock and Adams counties; (3) the Illinoisan, which covered all of the state except the northwest county (Jo Daviess), the southern part of Calhoun county, and the seven southernmost counties; (4) the Iowan, which covered a part of northern Illinois, the exact area, however, being difficult to determine because of the effect of the subsequent glaciations; (5) the early Wisconsin, which covered the northeastern part of the state as far west as Peoria and as far south as Shelbyville; (6) the late Wisconsin, which extended to the west line of McHenry county and south to the town of Milford in Iroquois county.

The material transported by the glacier varied with the character of the rocks over which it passed. Granites, sandstones, limestones, shales, etc., were torn from their lodging places by the enormous denuding power of the ice sheet and ground up together. A pressure of forty pounds per square inch is exerted by a mass of ice one hundred feet thick, and these ice sheets were hundreds or possibly thousands of feet in thickness. The material carried along in the ice, especially the boulders and pebbles, became powerful agents for grinding and wearing away the surface over which the ice passed. Preglacial ridges and hills were rubbed down, valleys were filled with the debris, and the surface features were changed entirely. The mixture of materials deposited by the glacier is known as boulder clay, till, glacial drift, or simply drift. The average depth of this deposit over the state of Illinois is estimated as 115 feet.

Previous to the ice invasion, this region generally was not well suited to agriculture because of its rough and hilly character, as is shown by borings which indicate many preglacial valleys that later were filled with drift. The general effect of the glaciers was to change the surface from hilly to gently undulating. Only a few streams have done anything to change the topography, and these in only very limited areas. Most of the streams formerly flowed in broad, swampy sloughs rather than in distinct valleys.

THE GLACIATIONS OF LIVINGSTON COUNTY

Livingston county was entirely covered by the Illinoisan glacier, which partially leveled the region by rubbing down the hills and filling the valleys. The county was covered by a deposit of boulder clay. This glacier receded, and a long period elapsed, during which a soil was formed from the glacial material that had been deposited. This is the Sangamon soil and it is found only in deep borings, as when drilling wells. The Iowan glacier followed, but so far as is known, it did not touch this county. The early Wisconsin glacier came next, and covered the Illinoisan drift, building up three moraines.

The first or oldest moraine is the Minonk ridge, which is a part of the Bloomington morainic system. This ridge is from one to three miles wide and

crosses the southwest part of the county (see drainage map). The next moraine to be formed was the Cayuga-Chatsworth ridge, which is really one moraine, tho it is sometimes spoken of as two. It is not very distinct and is broken thru by the Vermilion river. It divides into two ridges for a short distance in the south part of the county in Township 25 North, Range 8 East, but unites again in Ford county. The largest and most important moraine of the county is the Marseilles, which enters the county in Township 30 North, Range 5 East, swings to the southeast and east and leaves the county in Township 29 North, Range 8 East. This ridge is from eight to ten miles wide and rises 75 to 100 feet above the land at the outer margin of the Cayuga-Chatworth moraine. It was pushed against the Cayuga moraine where for some distance the two moraines apparently form a single ridge.

The glacial drift is very much like that of other counties in this region. It consists of blue boulder clay containing beds or pockets of gravel and sand which form the source of the water supply. Altho rock outcrops occur along the Vermilion river, the average thickness of the drift is nearly 150 feet. The greatest depth of drift found thus far is in the south part of the town of Odell, where it is 360 feet deep. Three and one-half miles southwest of Odell the drift is 300 feet deep. Leverett, who has studied extensively the geology of this region, says, "There appear to be buried valleys traversing the county whose rock floors are 150 to 200 feet below the general level of the rock surface. In such valleys the drift is 300 feet in thickness."

THE ACTION OF WIND AND WATER

The deposit of glacial drift does not form the material of the present soil except in small areas. The rock flour produced by the grinding action of the glaciers has been reworked by the wind and deposited over practically all of the county to a depth of 12 to 40 inches. This wind-blown, or loessial, material now covering the level and less rolling areas, has been transformed into soil by weathering and the accumulation of organic matter. There is little doubt but that this wind-blown material was at one time fairly uniformly deposited over the exposed surface, but it has subsequently been removed in places by erosion, so that the boulder clay is exposed on some of the more rolling areas.

During the melting of the glacier the streams draining this area were frequently flooded, moving large amounts of rather coarse material, such as sand and gravel. This was deposited in the valleys, partly filling them. Later the streams cut down thru the fill, leaving gravel terraces. This gravel was afterward covered with the fine material that now constitutes the soil. These terraces occur principally along the Vermilion river. During the melting of the late Wisconsin glacier in northern Indiana and southern Michigan, some of the flood waters came westward across Iroquois, Ford, and Livingston counties, finding their way into the Vermilion river and thence into the Illinois. These floods formed the broad terraces in Townships 27 and 28 North, Ranges 5 and 6 East. The terrace area ends at the rock ridge which is exposed in the bottom of the river in Section 21, northwest of Pontiac.

A large glacial lake, known as Glacial Lake Morris, which formerly covered a very large part of Grundy county and extended south into the north-

1100 Early Wisconsin Intermorainal Areas

(a) UPLAND PRAIRIE SOILS

26	Brown silt loam
20	Black clay loam
60	Brown sandy loam
28.1	Brown silt loam on tight clay
1120.2	Gravelly black clay loam
28	Brown-gray silt loam on tight clay
264 1126.4	Brown silt loam on gravel
1126.5	Brown silt loam on rock

(b) UPLAND TIMBER SOILS

34	Yellow-gray silt loam
35	Yellow silt loam
964 1164	Yellow-gray sandy loam

(c) 1500 TERRACE SOILS

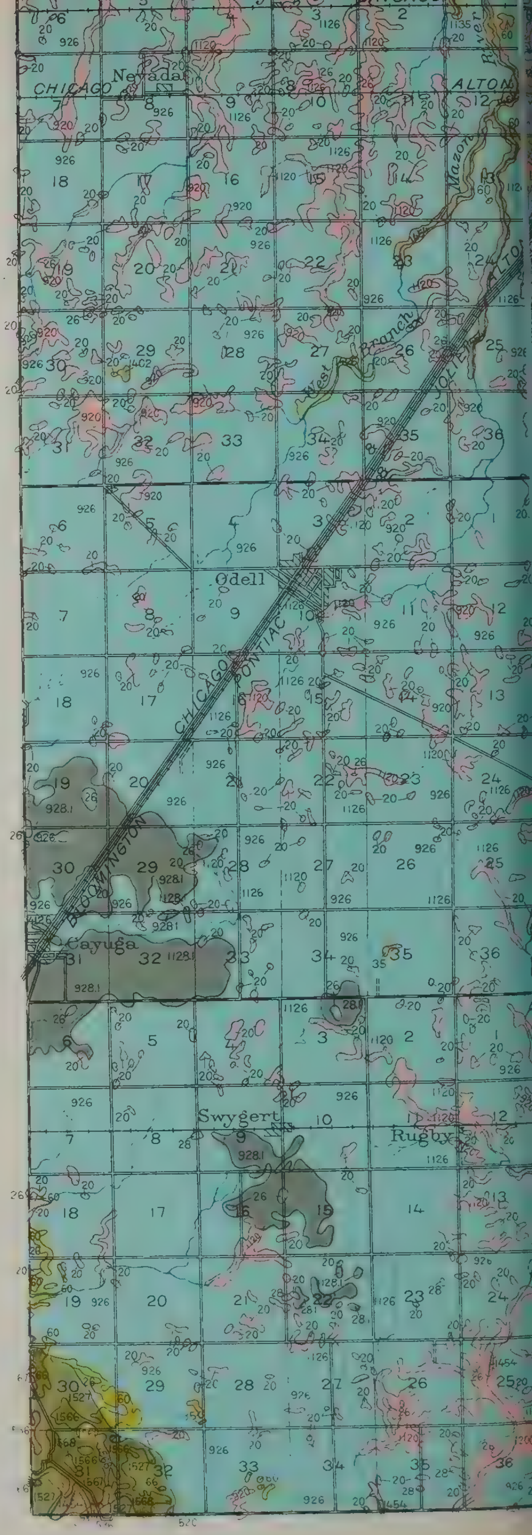
27 1527	Brown silt loam over gravel
66 1566	Brown sandy loam over gravel
20 1520	Black clay loam
1536	Yellow-gray silt loam over gravel
1526.4	Brown silt loam on gravel
1561	Black sandy loam
67 1567	Yellow-gray sandy loam over gravel
28 1528	Brown-gray silt loam on tight clay
1568	Brown-gray sandy loam on tight clay

(d) 1400 LATE SWAMP AND BOTTOM-LAND SOILS

1454	Mixed loam
1426	Deep brown silt loam
1401	Deep peat
1402	Medium peat on clay
1413.4	Muck on marl

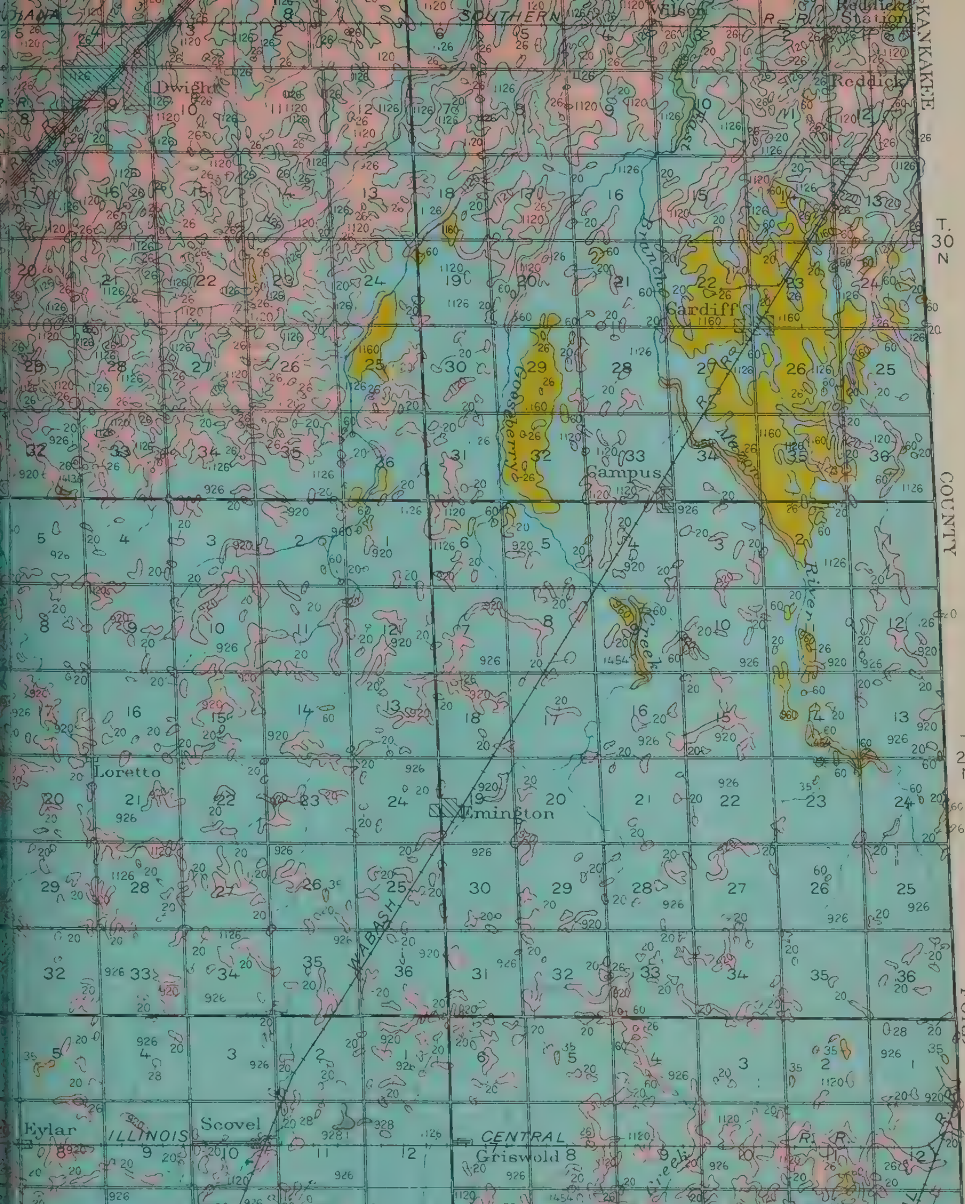
(e) 000 RESIDUAL SOIL

098	Stony loam



Scale

2 Miles



EY MAP OF LIVINGSTON COUNTY

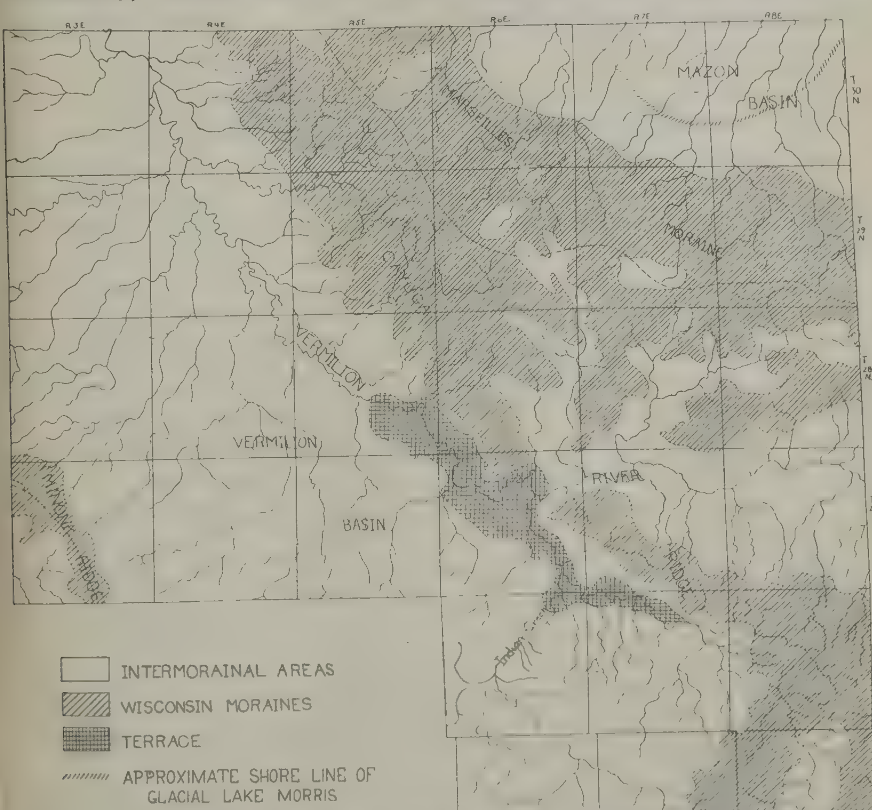
INOIS AGRICULTURAL EXPERIMENT STATION

eastern part of Livingston county in Township 30 North, Ranges 7 and 8 East, was responsible for the deposition of the large amount of black clay loam in that region.

PHYSIOGRAPHY AND DRAINAGE

In general Livingston county varies in topography from flat to rolling. There is no large amount of hilly land in the county, and the small area that does exist is found as bluffs along the bottom land of the Vermilion river. The variations in topography are due to three causes—the action of streams, of glaciers, and of wind. The latter, so far as it has modified topography, has been of no consequence except in the region north of Pontiac, where a few low sand dunes have been produced by the wind.

All the land of the county drains into the Illinois river, but thru various streams. The northeastern part, comprizing about eight townships, is drained by tributaries of the Mazon river; about twelve sections in the southwest corner have their outlet thru the Mackinaw river; while the remainder of the county, which forms a broad, flat valley, is drained by the Vermilion



MAP SHOWING THE DRAINAGE BASINS OF LIVINGSTON COUNTY WITH MORAINAL, INTERMORAINAL, AND TERRACE AREAS

river. Formerly, much of the county was swampy, and contained many ponds that rarely became dry. The extent of these areas is indicated generally by the amount of black clay loam. This district, with the aid of dredge ditches to furnish the outlets, has been thoroly tile-drained and now constitutes excellent agricultural land. The crest of the Marseilles moraine forms the divide between the Mazon river and the Vermilion river. The Minonk ridge is the divide between the Vermilion and Mackinaw rivers.

The altitude of Livingston county varies from 831 feet to less than 600. The following figures give the altitudes of certain places in the county. Ancona, 630 feet; Blackstone, 738; Budd, 705; Campus, 653; Cayuga, 691; Charlotte, 668; Chatsworth, 736; Cornell, 629; Dwight, 641; Emington, 701; Eylar, 698; Fairbury, 686; Flanagan, 676; Forrest, 688; Graymont, 657; Healey, 718; Lodemia, 658; Long Point, 641; Manville, 617; McDowell, 652; Missal, 668; Nevada, 680; Odell, 721; Pontiac, 647; Risk, 747; Rowe, 642; Saunemin, 686; Saxony, 696; Scovel, 694; Smithdale, 624; Strawn, 768; Sunbury, 660; Swygert, 737; Wilson, 615; Wing, 658. The altitude of the Marseilles moraine is from 740 to 755 feet. The highest point in the county, which is 831 feet, lies in the Cayuga ridge, in Section 5, Township 25 North, Range 8 East.

SOIL TYPES

The soils of Livingston county are divided into the following groups:

(a) *Upland Prairie Soils,* including the upland soils that have not been covered with forests, at least for any great length of time, and on which the luxuriant growth of prairie grasses has produced relatively large amounts of organic matter.

(b) *Upland Timber Soils,* including nearly all the upland areas that are now, or were formerly, covered with forests.

(c) *Terrace Soils,* including bench lands, or second bottom lands, formed by deposits from overloaded streams; and gravel outwash plains formed by broad sheets of water arising from the melting of the glaciers.

(d) *Swamp and Bottom-Land Soils,* including the overflow lands or flood plains along streams, the swamps, and the poorly drained lowlands.

(e) *Residual Soils,* including rock outcrop areas, and soils formed in place thru weathering of rocks.

Table 1 gives a list of the soil types found in Livingston county, the area of each type in square miles and in acres, and also its percentage of the total area. For example, we learn from the table that brown silt loam occupies about 775 square miles, or a little more than 496,000 acres, and that this type constitutes practically 75 percent of the total area of the county. The accompanying map shows the location and boundary of each type of soil, even down to areas of a few acres.

For explanations concerning the classification of soils and the interpretation of the map and tables, the reader is referred to the first part of the Appendix to this report.

900 Early Wisconsin Moraines

1100 Early Wisconsin Intermorainal Areas

(a) UPLAND PRAIRIE SOILS

- 26 Brown silt loam
- 20 Black clay loam
- 60 Brown sandy loam
- 28.1 Brown silt loam on tight clay
- 1120.2 Gravelly black clay loam
- 28 Brown-gray silt loam on tight clay
- 26.4 / 1126.4 Brown silt loam on gravel
- 1126.5 Brown silt loam on rock

(b) UPLAND TIMBER SOILS

- 34 Yellow-gray silt loam
- 35 Yellow silt loam
- 964 / 1164 Yellow-gray sandy loam

(c) 1500 TERRACE SOILS

- 27 / 1527 Brown silt loam over gravel
- 36 / 1536 Brown sandy loam over gravel

SOIL SURVEY MAP C

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Black clay loam

Yellow-gray silt loam over gravel

Brown silt loam on gravel

Black sandy loam

Yellow-gray sandy loam over gravel

Brown-gray silt loam on tight clay

Brown-gray sandy loam on tight clay

(d) 1400 LATE SWAMP AND BOTTOM-LAND SOILS

1454 Mixed loam

1426 Deep brown silt loam

Deep peat

1402 Medium peat on clay

1413.6 Muck on marl

(e) 000 RESIDUAL SOIL

098 Stony loam

Scale
0 ¼ ½ 1 2 Miles

LIVINGSTON COUNTY
LTURAL EXPERIMENT STATION

TABLE 1.—SOIL TYPES OF LIVINGSTON COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (900, 1100)			
−26	Brown silt loam	775.04	496,026	75.265
−20	Black clay loam	163.79	104,826	15.906
−60	Brown sandy loam	9.85	6,304	.956
−28.1	Brown silt loam on tight clay	15.74	10,074	1.529
−20.2	Gravelly black clay loam	.32	205	.031
−28	Brown-gray silt loam on tight clay	1.01	646	.099
−26.4	Brown silt loam on gravel	.27	173	.026
−26.5	Brown silt loam on rock	.14	89	.013
		966.16	618,343	93.825
	(b) Upland Timber Soils (900, 1100)			
−34	Yellow-gray silt loam	18.92	12,109	1.838
−35	Yellow silt loam	2.07	1,325	.202
−64	Yellow-gray sandy loam	.22	141	.021
		21.21	13,575	2.061
	(c) Terrace Soils (1500)			
−27	Brown silt loam over gravel	13.39	8,570	1.300
−66	Brown sandy loam over gravel	2.27	1,453	.220
−20	Black clay loam	1.27	813	.123
−36	Yellow-gray silt loam over gravel	1.87	1,197	.181
−26.4	Brown silt loam on gravel	.59	378	.057
−61	Black sandy loam	.05	32	.005
−67	Yellow-gray sandy loam over gravel	.26	166	.026
−28	Brown-gray silt loam on tight clay	.14	89	.013
−68	Brown-gray sandy loam on tight clay	.07	45	.007
		19.91	12,743	1.932
	(d) Late Swamp and Bottom-Land Soils (1400)			
−54	Mixed loam	20.96	13,414	2.036
−26	Deep brown silt loam	.50	320	.048
−01	Deep peat	.88	563	.085
−02	Medium peat on clay	.05	32	.005
−13.6	Muck on marl	.01	6	.001
		22.40	14,335	2.175
	(e) Residual Soil (000)			
−98	Stony loam	.02	13	.002
	(f) Miscellaneous			
	Rock quarries and gravel pits	05	32	.005
	Total	1,029 75	659,041	100.000

INVOICE OF PLANT FOOD IN LIVINGSTON COUNTY SOILS

SOIL ANALYSIS

The composition reported in the accompanying tables is, for the more extensive types, the average of several analyses. These analyses show that soils, like most things in nature, are variable; but for general purposes the average may be considered sufficient to characterize the soil type.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed, but it should be understood that

the rate of liberation, as explained in the Appendix (page 33), is governed by many factors.

For convenience in making practical application of the chemical analyses the results have been translated from the percentage basis and are presented here in terms of pounds per acre. In this, the assumption is made that for ordinary types a stratum of dry soil 6⅔ inches thick weighs 2,000,000 pounds. It is recognized that this value is only an approximation, but it is believed that it will suffice for the purposes intended. It is, of course, a simple matter to convert these figures back to the percentage basis in case one desires for any purpose to consider the information in that form.

THE SURFACE SOIL

In Table 2 are reported the amount of organic carbon (which serves as a measure of the organic matter), and the total quantities of nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium contained in 2 million pounds of the surface soil (the plowed soil of an acre about 6⅔ inches deep) of each type in Livingston county.

Because of the extreme variations frequently found within a given soil type with respect to the presence of limestone and acidity, no attempt is made to include in the tabulated results figures purporting to represent the average amounts of these substances present in the respective types. Such averages cannot give the farmer the specific information he needs regarding the lime requirements of a given field. Fortunately, however, very simple tests which can be made at home will furnish this important information, and these tests are described on pages 35 and 36 of the Appendix.

The variation among the different types of soil of Livingston county with respect to the content of important plant-food elements is very marked. For example, the deep peat contains, in the plowed soil of an acre, more than fifteen times as much nitrogen as the yellow-gray sandy loam. Comparing the deep peat with the most common type in the county, we find about five times as much nitrogen in it as in the brown silt loam, while on the other hand the brown silt loam contains nearly five times as much potassium as is found in the deep peat. The supply of phosphorus in the surface soil varies from 640 pounds per acre in the yellow-gray sandy loam over gravel to 2,010 pounds in the deep peat. A sulfur content of only 200 pounds per acre is found in the yellow-gray sandy loam over gravel, while in an equal volume of deep peat the analysis shows 2,500 pounds of this element. The magnesium varies in the different types from less than 3,000 to more than 16,000 pounds, and the calcium content ranges from 3,500 to nearly 40,000 pounds per acre.

It is important to note that some of the plant-food elements are present in very limited quantities as compared with crop requirements. Some simple computations are of interest in this connection. Assume, for example, that a four-field crop rotation of wheat, corn, oats, and clover yields 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. These are high yields, but not impossible for they are sometimes obtained. It will be found that the most prevalent upland soil of Livingston county, the brown silt

LEGEND

900 Early Wisconsin Moraines

1100 Early Wisconsin Intermorainal Areas

(a) UPLAND PRAIRIE SOILS

26	Brown silt loam
20	Black clay loam
60	Brown sandy loam
28.1	Brown silt loam on tight clay
1120.2	Gravelly black clay loam
28	Brown-gray silt loam on tight clay
26.4 1126.4	Brown silt loam on gravel
1126.5	Brown silt loam on rock

(b) UPLAND TIMBER SOILS

34	Yellow-gray silt loam
	Yellow silt loam
364 1164	Yellow-gray sandy loam

(c) 1500 TERRACE SOILS

27 1527	Brown silt loam over gravel
66 1566	Brown sandy loam over gravel
20 1520	Black clay loam
1536	Yellow-gray silt loam over gravel
1526.4	Brown silt loam on gravel
1561	Black sandy loam
67 1567	Yellow-gray sandy loam over gravel
28 1528	Brown-gray silt loam on tight clay
1568	Brown-gray sandy loam on tight clay

(d) 1400 LATE SWAMP AND BOTTOM-LAND SOILS

1454	Mixed loam
1426	Deep brown silt loam
1401	Deep peat
1402	Medium peat on clay
1413.8	Muck on marl

(e) 000 RESIDUAL SOIL

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VEY MAP OF LIVINGSTON COUNTY
LLINOIS AGRICULTURAL EXPERIMENT STATION

TABLE 2.—PLANT FOOD IN THE SOILS OF LIVINGSTON COUNTY, ILLINOIS: SURFACE SOIL
Average pounds per acre in 2 million pounds of surface soil (about 0-6⅔ inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (900, 1100)							
926 1126	Brown silt loam	63 770	5 130	1 050	1 000	38 010	9 590	10 840
1120	Black clay loam	64 100	5 790	1 470	1 100	39 730	16 090	20 270
1160	Brown sandy loam	40 400	3 330	650	780	27 500	4 630	6 680
928.1 1128.1	Brown silt loam on tight clay	55 690	4 730	1 080	950	41 870	11 490	9 740
1120.2	Gravelly black clay loam	87 120	7 960	1 780	1 640	29 160	12 880	22 660
1128	Brown-gray silt loam on tight clay	44 160	3 700	1 020	720	45 580	9 180	11 240
1126.4	Brown silt loam on gravel	44 060	3 740	1 060	860	35 380	8 260	8 440
1126.5	Brown silt loam on rock	48 380	4 620	1 260	300	28 720	6 580	10 400
	(b) Upland Timber Soils (900, 1100)							
1134	Yellow-gray silt loam	36 740	3 310	1 200	850	38 120	6 480	8 910
1135	Yellow silt loam	20 620	1 900	1 100	600	38 920	5 960	8 260
1164	Yellow-gray sandy loam	23 280	1 740	840	660	28 180	4 060	6 140
	(c) Terrace Soils (1500)							
1527	Brown silt loam over gravel	33 940	3 000	880	640	33 120	5 920	7 360
1566	Brown sandy loam over gravel	42 540	3 900	1 040	900	32 540	5 960	8 100
1520	Black clay loam	See figures for upland black clay loam (1120)						
1536	Yellow-gray silt loam over gravel	43 990	4 310	1 380	760	34 200	5 080	9 970
1526.4	Brown silt loam on gravel	34 940	3 280	960	940	35 120	8 380	9 080
1561	Black sandy loam	73 500	6 300	1 520	1 200	29 760	9 000	15 660
1567	Yellow-gray sandy loam over gravel	29 320	2 520	640	200	39 240	2 880	5 980
1528	Brown-gray silt loam on tight clay	70 380	6 980	1 300	640	38 720	5 300	11 700
1568	Brown-gray sandy loam on tight clay	43 600	3 420	740	720	25 260	4 120	8 660
	(d) Late Swamp and Bottom-Land Soils (1400)							
1454	Mixed loam[1]	....	....	....	....	....	....	....
1426	Deep brown silt loam	85 300	6 820	1 540	1 340	46 140	13 700	16 860
1401	Deep peat[2]	301 870	27 040	2 010	2 500	8 290	5 520	39 790
1402	Medium peat on clay[2]	161 290	13 890	1 380	2 220	15 690	7 180	17 800
1413.6	Muck on marl[3]	197 900	16 460	1 040	1 740	2 280	9 590	2 630
	(e) Residual Soils (000)							
098	Stony loam							

LIMESTONE AND SOIL ACIDITY.—In connection with these tabulated data it should be explained that the figures for limestone content and soil acidity are omitted, not because of any lack of importance of these factors but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm and even from field to field. Therefore no attempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, pages 35 and 36.

[1]On account of the heterogeneous character of mixed loam, chemical analyses are not included for this type.

[2]These amounts are based upon the assumption that the surface stratum contains 1 million pounds of soil, an estimate which is, of course, very crude.

[3]Based on an estimate of 1½ million pounds of soil per acre.

TABLE 3.—PLANT FOOD IN THE SOILS OF LIVINGSTON COUNTY, ILLINOIS: SUBSURFACE SOIL
Average pounds per acre in 4 million pounds of subsurface soil (about 6⅔-20 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (900, 1100)							
926 1126	Brown silt loam..........	74 710	6 480	1 580	1 380	78 900	25 770	19 510
1120	Black clay loam..........	67 730	6 380	2 350	1 300	81 190	34 640	38 540
1160	Brown sandy loam........	47 980	4 340	1 120	1 280	55 220	12 390	18 100
928.1 1128.1	Brown silt loam on tight clay..................	44 330	4 970	1 310	1 350	91 310	37 610	16 970
1120.2	Gravelly black clay loam...	78 360	6 720	2 560	1 680	63 680	26 320	38 800
1128	Brown-gray silt loam on tight clay..............	35 840	3 920	1 560	640	100 280	28 560	20 280
1126.4	Brown silt loam on gravel..	59 200	5,560	1 880	1 160	70 600	19 840	15 480
1126.5	Brown silt loam on rock,...	63 160	6 520	2 040	480	56 760	17 640	25 840
	(b) Upland Timber Soils (900, 1100)							
1134	Yellow-gray silt loam......	21 920	2 700	1 820	1 060	80 680	19 580	15 280
1135	Yellow silt loam..........	18 560	1 920	2 000	400	81 160	19 960	16 680
1164	Yellow-gray sandy loam....	11 080	1 080	1 480	720	56 600	7 920	9 440
	(c) Terrace Soils (1500)							
1527	Brown silt loam over gravel	57 560	5 160	1 720	1 080	68 560	15 120	16 720
1566	Brown sandy loam over gravel..................	61 440	5 880	1 800	1 480	66 120	13 960	15 320
1520	Black clay loam...........	See figures for upland black clay loam (1120)						
1536	Yellow-gray silt loam over gravel..................	32 300	4 060	1 900	780	69 820	13 120	16 420
1526.4	Brown silt loam on gravel..	55 200	5 960	1 680	1 640	71 120	20 560	17 520
1561	Black sandy loam.........	70 800	5 920	2 240	1 960	59 840	17 400	24 320
1567	Yellow-gray sandy loam over gravel............	18 720	2 400	1 200	680	62 840	9 720	12 720
1528	Brown-gray silt loam on tight clay..............	31 040	3 520	2 040	760	81 760	13 000	19 980
1568	Brown-gray sandy loam on tight clay..............	30 240	3 360	1 120	520	53 280	7 160	13 760
	(d) Late Swamp and Bottom-Land Soils (1400)							
1454	Mixed loam[1]..............	....	....	....	....	....	....	....
1426	Deep brown silt loam......	95 040	8 920	2 040	1 520	89 320	31 600	24 120
1401	Deep peat[2]...............	742 540	56 840	3 060	51 960	10 340	9 860	61 560
1402	Medium peat on clay[2].....	285 920	24 420	1 840	5 760	32 020	16 520	36 860
1413.6	Muck on marl............	117 240	9 560	1 840	3 320	65 160	40 200	85 560
	(e) Residual Soils (000)							
098	Stony loam...............							

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1]On account of the heterogeneous character of mixed loam, chemical analyses are not included for this type.

[2]Amounts reported are for 2 million pounds of deep peat and medium peat.

loam, contains only enough total nitrogen in the plowed soil, that is, in the surface stratum, 0 to 6⅔ inches, for the production of such yields to supply about ten rotations.

With respect to phosphorus, the condition differs only in degree, this soil containing no more of that essential element than would be required for about fourteen crop rotations yielding at the rates suggested above. On the other

TABLE 4.—PLANT FOOD IN THE SOILS OF LIVINGSTON COUNTY, ILLINOIS: SUBSOIL

Average pounds per acre in 6 million pounds of subsoil (about 20-40 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (900, 1100)							
926 1126	Brown silt loam	31 830	3 770	2 050	1 450	139 120	80 270	105 870
1120	Black clay loam	30 910	3 630	3 070	1 050	131 540	75 270	96 570
1160	Brown sandy loam	26 100	2 490	1 080	1 290	82 440	19 080	18 990
928.1 1128.1	Brown silt loam on tight clay	22 820	3 800	2 100	2 250[1]	170 400	93 580	85 680
1120.2	Gravelly black clay loam	42 600	4 020	2 700	1 260	91 260	42 120	57 900
1128	Brown-gray silt loam on tight clay	24 240	3 360	2 640	1 020	157 080	61 920	40 200
1126.4	Brown silt loam on gravel	29 400	3 600	2 100	1 260	110 220	54 420	75 960
	(b) Upland Timber Soils (900, 1100)							
1134	Yellow-gray silt loam	19 710	3 150	3 420	1 140	145 740	49 950	23 340
1135	Yellow silt loam	20 460	2 220	3 240	300	107 640	109 200	170 400
1164	Yellow-gray sandy loam	15 060	1 320	2 400	1 620	89 940	18 180	14 160
	(c) Terrace Soils (1500)							
1527	Brown silt loam over gravel	35 820	4 320	2 160	1 020	103 740	34 500	23 340
1566	Brown sandy loam over gravel	28 740	3 840	2 040	1 740	94 020	25 440	22 620
1520	Black clay loam	See figures for upland black clay loam (1120)						
1536	Yellow-gray silt loam over gravel	18 270	3 870	3 240	1 020	99 720	29 100	26 220
1526.4	Brown silt loam on gravel	52 500	6 180	2 640	1 260	114 300	38 340	26 640
1561	Black sandy loam	27 360	3 240	2 520	1 860	91 020	26 880	35 700
1567	Yellow-gray sandy loam over gravel	9 840	2 220	2 220	480	86 340	23 700	13 940
1528	Brown-gray silt loam on tight clay	24 360	4 260	3 240	1 260	122 520	29 340	28 800
1568	Brown-gray sandy loam on tight clay	19 980	2 760	1 380	540	83 160	29 700	20 160
	(d) Late Swamp and Bottom-Land Soils (1400)							
1454	Mixed loam[2]							
1426	Deep brown silt loam	62 100	6 420	2 280	1 020	147 000	48 480	28 620
1401	Deep peat[3]	889 800	69 600	2 820	153 570	14 220	19 050	154 350
1402	Medium peat on clay[4]	457 710	34 410	1 620	13 680	42 810	25 560	52 470
1413.6	Muck on marl	70 500	4 140	2 700	3 780	95 520	90 540	588 480
	(e) Residual Soils (000)							
098	Stony loam							

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1]One sample contained 51,780 pounds of sulfur per acre, which figure is excluded from the average for the type. See explanation on page 18.

[2]On account of the heterogeneous character of mixed loam, chemical analyses are not included for this type.

[3]Amounts reported are for 3 million pounds of deep peat.

[4]Amounts reported are for 3 million pounds, the same as for deep peat. For explanation see page 27.

hand the amount of potassium in the surface layer of this common soil type is equivalent to that which would be used in 472 years of such cropping provided the total crops were to be removed from the land; or, in case only the grain

were removed, this amount of potassium would supply such crops for about 30 centuries.

These general statements relating to the total quantities of these plant-food materials in the plowed soil of the most prevalent type in the county certainly emphasize the fact that the supplies of some of these necessary elements of fertility are extremely limited when measured by the needs of large crop yields for even one or two generations of people.

THE SUBSURFACE AND SUBSOIL

In Tables 3 and 4 are recorded the amounts of plant food in the subsurface and the subsoil of the different types. It should be remembered, however, that these supplies are of little value unless the top soil is kept rich. These tables also show great stores of potassium in the prevailing types of soil but only limited amounts of nitrogen and phosphorus, in agreement with the data for the corresponding surface samples.

DESCRIPTION OF INDIVIDUAL SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of Livingston county cover 966.16 square miles, or 93.8 percent of the area of the county. They usually occupy the less eroded areas of the upland. They are black or brown in color owing to their high organic-matter content. This land was originally covered with prairie grasses, the partially decayed roots of which have been the main source of the organic matter. The flat, poorly drained areas contain the greater amounts of organic matter owing to the more luxuriant growth of the grasses that grew on such areas and to the excessive moisture in the soil which provided conditions better adapted for the preservation of their roots.

Brown Silt Loam (926, 1126)

Brown silt loam is the most extensive type in Livingston county. It covers an area of 775.04 square miles, or practically 75 percent of the area of the county. In topography it varies from flat to slightly rolling. The more rolling phase is found in the northeast part of the county and on the Marseilles moraine.

While the brown silt loam is primarily a prairie type, timber has recently invaded it to a slight extent in some localities. The trees found on the timbered brown silt loam are usually bur oak, wild cherry, black walnut, ash, and elm, but their occupation of the soil has not been sufficiently long to change its character to any great extent.

In general the various strata of this type are formed from wind-blown loessial material, from boulder clay, or from material deposited in shallow water. A peculiar phase of the brown silt loam in this county is found on the moraines, where as a consequence of the removal of part of the fine loessial material the glacial drift is encountered at less than 30 inches from the surface; sometimes it even outcrops. On the steeper parts of the moraines erosion has taken place to such an extent that the brown soil is nearly all washed away and these areas,

if of sufficient size, are mapped as a different type, such as yellow silt loam (–35) if very steep, or yellow-gray silt loam (—34) if not so steep. Many such areas are too small to be represented on the map. In general the brown silt loam of the moraines (926), containing as it does less organic matter than the average, is affected to some extent by the tighter subsoil formed by the glacial drift. If the drift is rather compact, as is occasionally the case, the subsoil is somewhat inferior, owing to interference with drainage. This condition is indicated by a grayish color appearing after the soil becomes dry following a rain. Fortunately, however, this condition does not occur very frequently nor does it include large areas, since most of the glacial drift is pervious and some is even gravelly.

Large areas of the county were at one time covered by temporary lakes. In these lakes a deposit of rather fine-grained clay was made which was later covered by ordinary soil material. In this way a rather heavy subsoil was formed somewhat to the detriment of the drainage. This heavy phase merges into the condition represented by the type mapped as brown silt loam on tight clay (—28.1), a typical area of which occurs on Cayuga ridge.

The surface soil, 0 to 6⅔ inches, is a brown silt loam varying from a yellowish brown on the more rolling areas to a dark brown or black on the more nearly level and poorly drained tracts. In physical composition it varies to some extent, but it normally contains from 55 to 75 percent of the different grades of silt. In the lower areas the proportion of clay is usually higher than on the more rolling parts, where a perceptible amount of sand may occur. With the flooding of some parts of the county during the time of the melting of the glacier, more or less sand was carried in and deposited on the shores of the flooded parts. Some of this sand was later carried to the higher lands by the wind and became mixed with the soil, forming a sandy loam or a sandy phase of the silt loam.

The organic-matter content of the surface soil varies from 4 to 7 percent, depending on topography, and averages about 5.4 percent, or 54 tons per acre. In small areas on the more rolling parts of the moraines erosion has occurred to such an extent that the organic matter is rather low.

The natural subsurface is represented by a stratum which varies from 4 to 18 inches in thickness. This variation is due either to erosion, or to the fact that shallower-rooting grasses usually grew on the higher and better drained land, or perhaps to both of these causes. Erosion has removed some of the surface soil from the steeper parts and deposited it on the lower land, thus leaving a thinner layer of the dark soil in one case and producing a thicker one in the other. The physical composition of the subsurface varies in somewhat the same manner as the surface soil. In some parts, especially on the moraines, glacial till constitutes a part or all of the subsurface. The organic-matter content of the subsurface (6⅔ to 20 inches) is about 3.1 percent, or 62 tons per acre. In color this stratum varies from a dark brown or almost black to a yellowish brown, always changing to a lighter color with increasing depth.

The natural subsoil begins at a depth of 12 to 22 inches and extends to an indefinite depth. It varies from a yellow to a drabbish yellow, silty, clayey material, sometimes composed partially or even wholly of boulder clay. In the flat areas, however, not subject to erosion but where material has been

washed in from the higher surrounding land, the subsoil to a depth of 40 inches may not reach the boulder clay. The average depth to till is about 36 inches.

Management.—When the virgin brown silt loam was first cropped it was in fine tilth, it worked easily, and large crops could be grown with much less work than now. Continuous cropping to corn or to corn and oats, with the burning of corn stalks, stubble, grass, and even straw in many cases, has in a great measure destroyed the tilth, so that the soil becomes more difficult to work, washes badly, runs together, and bakes more readily than formerly. Unless the moisture conditions are very favorable, the ground will plow up cloddy, with the result that unless well-distributed rains follow, a good seed bed is difficult to produce. The clods may remain all season. Much plant-food material will be locked up in them, and the best results cannot be obtained. This condition of poor tilth may become serious if the present methods of management continue; in some cases it is already one of the factors that limit crop yields. The remedy is to use a rotation which includes a clover crop and to increase the organic-matter content by plowing under every available form of vegetable material, such as farm manure, corn stalks, straw, clover, stubble, and even weeds. Fresh organic matter is not only of great value in improving the physical condition of this type of soil, but it is also important because of its nitrogen content. Furthermore, as it decays it liberates mineral plant-food elements such as potassium, of which there is an inexhaustible supply in the soil, and phosphorus from the phosphate contained in or applied to the soil.

The deficiency of organic matter in the soil is shown by the way the fall-plowed land runs together during the winter, or at any time when heavy rains occur. In the spring following fall plowing, the land should be disked early and deep for the purpose of conserving moisture, raising the temperature, and making plant food available.

On most of the brown silt loam in Livingston county, limestone is already becoming deficient in the upper strata, altho it usually exists in considerable quantity in the subsoil. If the tests for carbonates and acidity described in the Appendix, pages 35 and 36, indicate the need of limestone, or if because of lime deficiency such crops as sweet clover and alfalfa fail to grow well, an application of about 2 tons of limestone per acre is recommended.

Rock phosphate has been used on many farms in Livingston county with apparently very beneficial results. The results of the field experiments in the use of this material will be found in the Supplement. In applying rock phosphate not less than one-half ton per acre should be used as the initial application, with a half-ton for each subsequent crop rotation. Under such treatment the phosphorus content of the soil will be gradually increased so that the time will come when the applications may be discontinued for a time. At just what point the law of diminishing returns comes into effect remains for experience to determine.

Suggestions for practical systems of cropping will be found in the discussion of crop rotations in the Appendix, on page 42. For the results of actual field experiments in improving the soil of the brown silt loam type the reader is referred to pages 45 to 54 of the Supplement.

Black Clay Loam (920, 1120)

Black clay loam represents the flat prairie land that was formerly swampy. It is sometimes called "gumbo" because of its sticky character. Its occurrence in the flat, poorly drained areas is due to the accumulation of organic matter and to the washing in of clay and fine silt from the higher areas.

Black clay loam presents many variations. It may change with a difference of only a foot or two in elevation. In this county, as elsewhere, the boundary lines between the black clay loam and the brown silt loam are not always distinct. Sometimes on the border between these two types the subsoil is distinctly that of black clay loam, while the surface soil is very silty, or is a good brown silt loam. The washing in of silty material from the surrounding higher lands, especially near the edges of the areas, modifies the character of the soil, giving it a brown silt loam surface. With the annual cultivation of the soil, this change is taking place more rapidly now than formerly when washing was largely prevented by prairie grasses. Many small areas of black clay loam in the more rolling parts are being slowly buried by this process.

This type is very widely distributed over the county, as is shown by the fact that, aside from the timber and terrace areas where this type would be expected to occur only rarely, there are but ten sections that do not have an area of black clay loam large enough to map. It occurs in areas that were formerly sloughs and ponds, and even in the small kettle-hole ponds on the moraines, altho most of these are so small that they cannot be shown on the map. There are many large areas of the type, as in Township 30 North, Ranges 7 and 8 East, Township 27 North, Range 7 East, and a strip eight or ten miles wide west of the Vermilion river. Altogether this type covers an area of 163.79 square miles, or about 16 percent of the total area of the county.

The surface soil, 0 to 6⅔ inches, is a black, plastic, granular, clay loam varying locally to a black clayey silt loam, or even to a black sandy clay loam which may contain gravel. These variations in physical composition occur as the type merges into other types. In some places that were formerly sloughs, the water has deposited gravel in sufficient abundance to form what is mapped as gravelly black clay loam (—20.2). Recent erosion has occasionally covered the black clay loam with several inches of dark or black, silty material, which often makes it difficult to draw the soil boundary. If erosion continues, as it undoubtedly will, the soil boundary may be changed entirely by the burying of the black clay loam with brown silt loam. The organic-matter content varies from 5.1 to 10.6 percent, with an average of 6.2 percent or 62 tons per acre. The organic matter in the kettle-hole depressions on the moraines is sometimes very high.

The natural subsurface stratum has a thickness of 10 to 20 inches. It varies from a black to a brownish drab clay loam and is usually somewhat heavier than the surface soil. It grades into a dull yellow or a drabbish or olive-colored material with increasing depth. The average organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 3 percent, or 60 tons per acre. The stratum is usually rather pervious to water, owing to jointing or checking from shrinkage in times of drouth, to the penetration of plant roots, and to the action of crayfish and other animals. Some exceptions to this are

found where it grades toward brown-gray silt loam on tight clay (1128) and brown silt loam on tight clay (1128.1). Here the lower strata become somewhat impervious and drainage is slow.

The subsoil to a depth of 40 inches varies in composition from a clayey silt to a very heavy clay, and in color from a dull drabbish yellow to drab or olive. Areas of the heavier phase are found in Townships 29 and 30 North, Ranges 4 and 5 East. Because of poor natural drainage, the iron in the subsoil is not highly oxidized. Concretions of calcium carbonate are frequently found. The perviousness of the subsoil is about the same as that of the subsurface and is due to the same causes. When thrown out on the surface where wetting and drying may take place, this clayey material soon breaks into small, irregular masses about one-fourth to one-half inch square in section.

Management.—Drainage is the first requirement in the management of this type and, if the outlet is obtainable, this may usually be effected with little difficulty. Thoro drainage helps to keep the soil in good physical condition.

After the organic matter is necessarily destroyed by the process of nitrification, and after the limestone is removed by cropping and leaching, the physical condition of the soil becomes poorer, and as a consequence more difficult to work. Both organic matter and limestone tend to develop granulation and mellowness, which are very essential with heavy soils. The organic matter should be maintained by turning under manure and such crop residues as corn stalks and straw, and by the use of clover and pasture in rotations.

In many cases the use of limestone will probably be of little or no value on this soil because the subsoil and subsurface are naturally charged with carbonates, and in some instances even the surface soil contains carbonates. Because of exceptions to these conditions, however, it is recommended that the tests for acidity and carbonates described in the Appendix, pages 35 and 36, be made; and if carbonates are not found within a foot of the surface, a moderate application of limestone, about 2 tons per acre, should be made.

Altho the black clay loam is one of the most productive soils in the state, it has a tendency to shrink and expand to such a degree as to be objectionable at times, especially during drouth. This results in the formation of cracks, which are sometimes as much as two or more inches in width at the surface and extend with lessening width to two or three feet in depth. These cracks allow the soil to dry out rapidly, and as a result the crop is injured thru lack of moisture. They do much damage by "blocking out" hills of corn and severing the roots. While cracking may not be prevented entirely, good tilth with a soil mulch will do much toward that end. Cultivation is more essential on this type, both for aeration and for the conservation of moisture, than on almost any other type in the county. It must be remembered, however, that cultivation should be as shallow as possible in order to prevent injury to the roots of the growing crop. (See Bulletin 181.)

Occasional small patches of alkali soil are found in areas of black clay loam. These spots are indicated by the fact that oats lodge badly and corn makes a poor growth, usually turning yellow or brown. If the amount of alkali is large, the corn may not grow to a height of more than two or three feet and will have a bushy appearance. Even if it reaches almost normal

height, it does not produce much grain. The fragments of shells that are frequently found are indications of alkali. A sweet clover crop turned under is probably the best remedy. Good underdrainage should be provided.

Brown Sandy Loam (960, 1160)

The brown sandy loam of the upland is confined principally to four areas, as follows: Townships 29 and 30 North, Range 8 East; Township 28 North, Range 8 East; Township 25 North, Ranges 7 and 8 East; and Township 28 North, Range 5 East. In the formation of this type it seems probable that at one time the sand was laid down on the shore lines of old lakes and was later reworked to some extent by the wind. Other types of soil lying in proximity to the brown sandy loam contain more sand than normally occurs. The total area of brown sandy loam in the county is 9.85 square miles or 6,304 acres.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam varying in color from light brown to black, and in physical composition from a loam with about 50 percent of sand to a very sandy loam carrying 75 percent, or slightly more, of sand. A representative sample would contain from 60 to 65 percent of sand, mostly of medium grade. Many small areas of sand are found in this type but they are too small to be shown separately on the map. The organic-matter content is about 3.2 percent, or 32 tons per acre.

The natural subsurface stratum varies in thickness from 7 to 12 inches, and in color from dark brown to brownish yellow, usually passing into a yellow sandy silt or silty sand in the lower part of the stratum. In physical composition it varies even more than the surface layer. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 1.7 percent, or 34 tons per acre.

The subsoil varies both in color and in physical composition. The color may be a bright yellow under conditions of good drainage, or a grayish yellow where the water table has been rather high. In composition, it may be sand, sandy silt, or sandy clayey silt.

Management.—The type is not very well supplied with plant food. In order to increase the nitrogen and organic matter, legumes must be grown, manure should be applied, and crop residues plowed under. Before clovers can be grown at their best, limestone to the amount of 2 or 3 tons per acre should be applied.

According to the analytical data given in Tables 2, 3, and 4, brown sandy loam is among the poorest in phosphorus of all the soil types in the county, which fact suggests that sooner or later provision must be made for correcting this deficiency. Unfortunately the Experiment Station has no experiment field on this particular soil type from which information might be drawn regarding the best form of phosphatic material to apply. The low organic content of this type of soil would suggest a possible advantage in using a directly available form of phosphate, such as steamed bone meal or acid phosphate. One hundred pounds of steamed bone meal or 200 pounds of acid phosphate of good quality will return to the soil as much of the element phosphorus as is contained in 50 bushels of wheat or 70 bushels of corn. Alfalfa and soybeans ought to do well on this soil.

Brown Silt Loam on Tight Clay (928.1, 1128.1)

Brown silt loam on tight clay occurs on the northern half of Cayuga ridge in broken or disconnected areas. The type covers an area of 15.74 square miles, or 1.5 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a brown silt loam which shows a gray color when it dries after a rain. The color is not uniform but varies so as to give the field a spotted appearance. The stratum contains about 4.8 percent of organic matter, or 48 tons per acre.

The natural subsurface soil is a layer from 4 to 18 inches thick consisting of a brown silt loam which passes into a compact, brownish yellow, impervious material. The stratum sampled (6⅔ to 20 inches) contains about 1.9 percent of organic matter.

The subsoil consists of yellowish or drabbish yellow compact material that does not permit the ready passage of air or water. The origin of this tight subsoil is difficult to explain. A similar case occurs in Iroquois county, where there is little doubt but that the subsoil was deposited in a shallow lake. One possible explanation is that the material composing this tight stratum may have been deposited during a period of recession of the glacier. When the glacier advanced, this material was pushed forward, and upon the melting of the ice was deposited upon the moraine, where it has been subsequently covered by a few inches of wind-blown material which now constitutes the soil.

One of the samples of subsoil collected showed an extremely high sulfur content amounting to 51,780 pounds per acre. Upon resampling this area, a thin deposit of white substance was found at a depth of 35 to 40 inches which, upon chemical examination, appeared to be calcium sulfate. Since this seemed to be a local abnormality, the sulfur determination for this sample is excluded from the average given in Table 4.

Management.—This type is lacking in limestone in the upper two strata, but the subsoil seems to contain a considerable supply of this material. For legumes, it is therefore necessary to apply limestone. Sweet clover is the best legume to grow, as its roots have the greatest power of penetration, even greater than those of alfalfa.

Gravelly Black Clay Loam (1120.2)

Much of the black clay loam contains some gravel, but only in a few places is the gravel sufficiently abundant to form the type, gravelly black clay loam, in areas large enough to be shown as such on the map. Small areas of an acre or two are frequently met. The type occurs principally in places that were formerly sloughs containing streams which at times became swift currents. The total area of gravelly black clay loam as mapped is 205 acres, and it is confined mostly to Township 27 North, Range 6 East.

The surface soil, 0 to 6⅔ inches, is a black, granular, plastic, gravelly clay loam with some sand. The content of gravel varies from 20 to 30 percent. Most of the pebbles are smaller than a half inch in diameter. This stratum contains about 7.5 percent of organic matter, or 75 tons per acre.

The natural subsurface is a layer from 8 to 14 inches in thickness. It differs but little from the surface except that it becomes lighter in color with in-

creasing depth until it passes into a drab or a grayish yellow. The organic matter of the sample collected (6⅔ to 20 inches) was approximately 3.4 percent, or 68 tons per acre.

The natural subsoil, extending to 40 inches, is somewhat more variable than the other strata but is usually a silty clay with sand and gravel. It contains about 1.2 percent of organic matter.

Management.—This type is well supplied with the elements of plant food. It should be managed in the same manner as the black clay loam (–20).

Brown-Gray Silt Loam on Tight Clay (928, 1128)

Brown-gray silt loam on tight clay is widely scattered over the county, but it usually occurs in small areas. Many spots of this type, too small to be shown on the map, are included in areas of brown silt loam (—26). These spots usually occur as shallow depressions. The total area in this county, as mapped, amounts to just about one square mile.

The surface soil, 0 to 6⅔ inches, varies from a grayish brown to brown silt loam. It contains about 3.8 percent of organic matter, or 38 tons per acre.

The natural subsurface is a layer from 6 to 12 inches thick. It is a gray to brownish gray silt loam with about 1.5 percent of organic matter in the stratum sampled (6⅔ to 20 inches).

The subsoil is a brownish yellow clay, tough, plastic, and impervious.

Management.—Drainage is very necessary in the improvement of this type, but the impervious character of both subsurface and subsoil makes this land rather difficult to drain. The lines of tile must be placed much closer than in the draining of brown silt loam (—26).

The type is rather meagerly supplied with the elements of plant food and it appears to be acid in the surface stratum. The growing of legumes and the turning under of manure and crop residues will supply nitrogen, but in order to secure the best growth of legumes limestone should be applied. Sweet clover is recommended as one of the best crops to grow. After these needs are satisfied probably phosphorus will prove to be beneficial.

Brown Silt Loam on Gravel (1126.4)

Brown silt loam on gravel occurs only in Sections 13 and 14 in Township 27 North, Range 7 East, where a gravel ridge has been covered with silt. The total area is only 173 acres.

The surface soil, 0 to 6⅔ inches, is a brown silt loam with some sand. It has about 3.8 percent of organic matter, or 38 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a brown to brownish yellow silt loam, containing about 2.5 percent of organic matter.

The subsoil is made up chiefly of gravel, which first appears at depths varying from 16 to 30 inches.

Management.—The management of the type should be the same as that recommended for brown silt loam (—26) except that, on account of the relatively shallow reservoir for holding moisture, a large amount of organic matter is even more essential than on brown silt loam. For the same reason early maturing crops should be grown.

Brown Silt Loam on Rock (1126.5)

The total area of brown silt loam on rock in the county is 89 acres and it is found in Sections 15 and 16, Township 28 North, Range 5 East. The rock is limestone.

The surface soil, 0 to 6⅔ inches, is a brown silt loam with about 4.2 percent of organic matter, or 42 tons per acre.

The subsurface is sampled to 20 inches in depth where possible. Rock is found at depths varying from 15 to 30 inches. The subsurface as sampled contains about 2.7 percent of organic matter.

Management.—Shallow soils underlain by rock usually do not withstand drouth to any great extent; therefore in the management of this type it would be well to use early maturing crops, as these will be affected least by drouth. In other respects the type should be managed about the same as the ordinary brown silt loam (—26). If the soil is very shallow it will probably be best to give the land over to permanent pasture.

(b) UPLAND TIMBER SOILS

The upland timber soils include nearly all the upland areas that are now, or have been, covered with forests. These soils contain much less organic matter than those of the prairie. In forests the vegetable material from trees accumulates upon the surface and is either burned or suffers almost complete decay. Grasses, which furnish large amounts of humus-forming roots, do not grow to any extent because of the shade. Moreover, the organic matter that had accumulated before the timber began growing is removed thru various decomposition processes, with the result that in these soils generally the content of nitrogen and organic-matter has become too low for the best growth of farm crops.

The total area of upland timber soils in Livingston county is 21.21 square miles, or about 2 percent of the area of the county.

Yellow-Gray Silt Loam (934, 1134)

Yellow-gray silt loam is not very extensive in this county, altho it is distributed along most of the courses of the larger streams, where it forms a narrow belt on either side. The type as mapped includes some narrow, steep slopes along the bottom lands of streams, that are really yellow silt loam but are too narrow to be shown as such on the map. In topography, it is undulating to slightly rolling and usually has good surface drainage. White oak and hickory are trees commonly found. The area covered by this type is 18.92 square miles. or about 12,000 acres.

The surface soil, 0 to 6⅔ inches, is a gray or yellowish gray silt loam, incoherent and mealy, but not granular. In physical composition it varies according to its relation to other types. Where it occurs in the sandy loam areas it sometimes becomes somewhat sandy, and very small areas may contain enough sand to be mapped as yellow-gray sandy loam. The organic-matter content averages about 2.7 percent, or 27 tons per acre. The amount increases where the type grades into the brown silt loam which usually borders it.

The natural subsurface stratum varies from 3 to 10 inches in thickness. In color it is gray, grayish yellow, or yellow. It is somewhat pulverulent, but becomes more coherent and plastic with increasing depth. The amount of organic matter of the stratum sampled (6⅔ to 20 inches) is about .9 percent.

The subsoil is a yellow or grayish yellow clayey silt or silty clay, somewhat plastic when wet but pervious to water. Sometimes the subsoil is made up wholly or in part of glacial material.

Management.—In the management of yellow-gray silt loam, one of the essential considerations is the maintenance or increase of organic matter. This is even more necessary with the yellow-gray silt loam than with the brown silt loam because of the fact that this soil is naturally much lower in organic matter, having only about one-half as much as the brown silt loam. The deficiency in organic matter permits the soil particles to run together, in the wetting by heavy rains. Organic matter will help to prevent washing on the more rolling areas. As it decays, it supplies nitrogen and at the same time tends to liberate other plant-food elements, as explained in the Appendix.

In the areas sampled, the soil is acid, thus making it necessary to apply 2 or 3 tons of ground limestone per acre before the best results can be obtained with legumes. Later applications may be smaller. The growth of legumes is very essential since they furnish organic matter to turn back into the soil and at the same time supply the necessary nitrogen. But all forms of organic matter, such as corn stalks, manure, and weeds are of value and they should be turned into the soil rather than burned.

On the experiment field in Lake county representing this soil type, excellent results have been obtained by the use of steamed bone meal.

Yellow Silt Loam (935, 1135)

Yellow silt loam is found on steep slopes along the streams and on the steepest parts of moraines. It covers an area of 1,325 acres.

The surface soil, 0 to 6⅔ inches, consists of a yellow to brownish yellow silt loam varying in composition from a sandy phase on the one hand, to a rather heavy phase on the other. The surface stratum contains about 3.2 percent of organic matter, or 32 tons per acre.

The subsurface is a yellow silty or sandy material varying toward a silty clay. The stratum contains about one percent of organic matter.

The subsoil is a yellow clayey silt and in many cases is formed from boulder clay.

This type is usually not under cultivation and practically the only way in which it can be used is as pasture or as woodland.

Yellow-Gray Sandy Loam (964, 1164)

With only a few exceptions, yellow-gray sandy loam occurs adjacent to the streams in a manner similar to yellow-gray silt loam. The type is usually slightly rolling. It covers an area of 141 acres.

The surface soil, 0 to 6⅔ inches, is a gray to yellow-gray sandy loam containing about 2 percent of organic matter, or 20 tons per acre.

The subsurface is a sandy loam varying in color from yellow to grayish yellow. It contains .5 percent of organic matter.

The subsoil varies considerably, being made up in some places of a yellowish, sandy, clayey material, while in others it is composed of boulder clay, and in still others of sand.

Management.—As a type, yellow-gray sandy loam is somewhat inferior to most other soils of the county. It is low in practically all elements of fertility. In the samples analyzed, carbonates were lacking even in the subsoil. Where such a condition exists, 2 to 4 tons of limestone per acre should be applied so that legumes will grow well. The legumes should be turned under in order to increase the amount of nitrogen, which is now much too low for a productive soil. All organic residues should be put back into the soil for the same purpose. The type is low in phosphorus, and ultimately this element must be supplied if the best results are to be obtained in the growth of crops. The same remarks regarding phosphorus apply here as are given in connection with brown sandy loam (—60).

(c) TERRACE SOILS

The terrace soils in this county were formed by the flooding of a valley during the melting of the glacier. The stream carried large amounts of coarse sand and gravel which were deposited as its velocity decreased. Finer material later deposited over this sand and gravel forms the present soil. When the stream reached its normal size after the glacier had melted, it cut down thru the deposit so deep that the terrace is no longer flooded at times of overflow. The depth of the finer material that forms the soil varies in this county from about 16 inches to four or five feet. The value of these soils depends much upon the depth to gravel. If the gravel is too near the surface, the crops may suffer from drouth. The total area of terrace soils in Livingston county is about 20 square miles.

Brown Silt Loam over Gravel (1527)

Brown silt loam over gravel is found along the Vermilion river above the rock ledge or rock ridge which the river crosses just below Pontiac. The topography is usually flat to undulating. The total area is 13.39 square miles, or 1.3 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a little lighter in color than the upland brown silt loam. It varies somewhat in composition, being distinctly sandy in some places. It contains about 2.9 percent of organic matter, or 29 tons per acre.

The natural subsurface consists of a silt loam stratum varying from 6 to 12 inches in thickness. It varies in color from brown to light brown. The stratum sampled (6⅔ to 20 inches) contains about 2.5 percent of organic matter, or 50 tons per acre.

The subsoil varies from a yellow silt to a yellow sandy silt. In most instances gravel is found at a depth of 30 to 48 inches. This provides good drainage where the water table is sufficiently low.

Management.—In the samples examined, all strata of this type were acid. In cases where this is the condition, 2 or 3 tons of limestone will be required

as an initial application in order to provide favorable conditions for the growth of legumes. Later applications should be made in quantity sufficient to maintain these conditions. The same need for applying phosphorus and for turning under legumes and organic residues exists in this type as in the upland brown silt loam. Excellent results have been obtained in the use of rock phosphate in building up land on this soil type.

Brown Sandy Loam over Gravel (1566)

Brown sandy loam over gravel occurs along the Vermilion river. It owes its formation to the same general processes as the preceding type (1527). It includes a total area of 1,453 acres.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam varying on the one hand to brown silt loam, and on the other to sand. It contains about 3.8 percent of organic matter, or 38 tons per acre.

The subsurface is a brown sandy loam, passing into a yellowish sandy silt at a depth of about 15 inches. It contains about 1.6 percent of organic matter.

The subsoil is a yellow sandy silt varying to a silt. The gravel is sometimes found at a depth of less than 40 inches altho it usually occurs at greater depths.

Management.—In the sample analyzed, all strata were acid. Where this condition occurs it will be necessary to apply 2 or 3 tons of limestone to secure the best results with legumes. The same use must be made of organic residues and manure as recommended for the preceding type. The remarks made in connection with the management of brown sandy loam, page 17, will also apply here.

Black Clay Loam (1520)

A few areas of black clay loam occur in the poorly drained parts of the terrace. This type covers a total of 813 acres. It differs but little, if any, from the upland type of black clay loam. (See page 15.)

Yellow-Gray Silt Loam over Gravel (1536)

Yellow-gray silt loam over gravel occurs along the upper course of the Vermilion river and its two tributaries—Indian and Forrest creeks. The total area of the type is 1,197 acres.

The surface soil, 0 to 6⅔ inches, is a yellowish or grayish yellow silt loam varying in sand content to a loam and in some places even to a sandy loam.

The subsurface soil is a yellow silt loam.

The subsoil is a yellow silty clay or clayey silt, underlain by medium gravel, which is generally below 40 inches.

Management.—In the management of this type, one of the first requirements is an application of 2 to 3 tons of limestone in order to correct the acidity which in the subsoil becomes very high. The low content of organic matter demands that legumes be grown and that the best use be made of crop residues, and manure. Along with the improvement in this way, it would be of benefit to apply some form of phosphate—probably one of the more available forms,

such as bone meal or acid phosphate, would be preferable. This would be a good soil for alfalfa, as it is generally well drained owing to the underlying stratum of gravel.

Brown Silt Loam on Gravel (1526.4)

Brown silt loam on gravel occurs to a limited extent along Indian and Forrest creeks west of Forrest. It covers only 378 acres.

The surface soil, 0 to 6⅔ inches, is lighter in color than the upland brown silt loam. It contains about 3 percent of organic matter.

The subsurface soil is a yellowish brown or brownish yellow silt loam.

The subsoil is a yellow sandy or gravelly silt loam passing into gravel at a depth of about 16 to 28 inches.

Management.—This type requires the same treatment as brown silt loam on gravel of the upland (1126.4).

Black Sandy Loam (1561)

Black sandy loam occurs to the extent of only 32 acres.

The surface soil is a black sandy loam containing 6.3 percent of organic matter.

The subsurface soil is a sandy loam changing from black to drabbish yellow and carrying about 3 percent of organic matter.

The subsoil is a drabbish yellow sandy loam containing some coarse sand.

Management.—Good cultivation, together with the application of limestone when the soil becomes deficient in this constituent, is the essential thing in handling this land.

Yellow-Gray Sandy Loam over Gravel (1567)

Yellow-gray sandy loam over gravel occurs along the streams in a manner similar to that of brown sandy loam over gravel, but it has been timbered sufficiently long to reduce the organic matter to a very small amount. This type covers an area of 166 acres.

The surface soil, 0 to 6⅔ inches, is a gray to light yellow sandy loam. It ranges in texture from a loam to a very sandy phase of sandy loam. It contains about 2.5 percent of organic matter, or 25 tons per acre.

The subsurface soil is a gray or yellowish gray sandy loam, passing into the heavier phase characteristic of the subsoil at a depth of about 15 to 17 inches.

The subsoil consists usually of a sandy, clayey material that is underlain by gravel at a depth of 36 to 54 inches.

Management.—Since this type is very low in nitrogen, containing only 2,520 pounds per acre in the plowed soil, the growing of legumes should receive primary consideration. The soil as sampled indicates the absence of limestone; therefore it is necessary to apply 2 to 4 tons per acre in order to produce the best growth of legumes. All available organic residues and farmyard manure must be turned under in order to increase and maintain the supply of organic matter and nitrogen. This soil is also very low in phosphorus and this element should be supplied as recommended for brown sandy loam, page 17.

Brown-Gray Silt Loam on Tight Clay (1528)

Brown-gray silt loam on tight clay is rather common in the terrace, altho the total area mapped as such amounts to only 89 acres. The individual areas are small, and there are many spots corresponding to this type that are too small to be shown on the map. They constitute small depressions of gray soil that formerly were ponds.

The surface soil, 0 to 6⅔ inches, is a grayish brown silt loam containing 6 percent of organic matter, which is a rather high percentage for this type.

The natural subsurface stratum, which is about 10 inches thick, is very gray in color.

The natural subsoil, which immediately underlies the gray stratum, is heavy and tight, and this may in turn be underlain by sand.

Management.—The type is fairly well supplied with elements of plant food, but in the area sampled the soil is acid, thus indicating that limestone is necessary in order to get the best results with legumes. Probably phosphate would be profitably applied on these areas. Drainage is very essential but is rather difficult to secure.

Brown-Gray Sandy Loam on Tight Clay (1568)

In some places where tight clay has formed, sand has been carried to the area either by wind or water, and there is formed a brown-gray sandy loam on tight clay that has the same characteristics as the preceding type except that it is not so well supplied with the elements of plant food. There are 45 acres of the type.

The surface soil, 0 to 6⅔ inches, is a brownish gray to gray sandy loam containing about 2.9 percent of organic matter, or 29 tons per acre.

The subsurface is a gray sandy loam underlain at 14 to 17 inches by a tough, tight, plastic, sandy clay. The stratum as sampled (6⅔ to 20 inches) contains about 1.3 percent of organic matter.

The subsoil is a tough, impervious, sandy clay that is underlain by coarse sand at a depth of 36 to 48 inches.

Management.—This soil is low in plant food. In order to improve it, limestone should be applied, legumes should be grown, and all available manure and other forms of organic matter should be plowed under. Phosphorus should also be supplied. See recommendations for brown sandy loam, page 17.

(d) LATE SWAMP AND BOTTOM-LAND SOILS

This group includes the bottom lands along the streams, the swamps, and the poorly drained lowlands. Much of the soil, therefore, is of alluvial formation and the land is largely subject to overflow. The swamps occupy low, marshy places. In former times these swamps became, during wet seasons, shallow ponds or lakes. Five types of this group are recognized in Livingston county, the total area of which aggregates 22.40 square miles, or about 2.17 percent of the county.

Mixed Loam (1454)

The common type of bottom land of Livingston county is mixed loam. It occurs in irregular strips, rarely more than a quarter of a mile wide, along the Vermilion river and its tributaries and also along the west branch of the Mazon river. It covers a total area of 20.96 square miles, or 13,414 acres. This type is a mixture of types, as its name implies; black clay loam, brown silt loam, brown loam, brown sandy loam, and even sand may all be found. Even if it were possible to indicate on the map the many variations, the effort would be useless because the next flood would probably leave a different mixture.

The surface soil, 0 to 6⅔ inches, is a mixed loam varying from clay loam to sand and, as sampled, containing approximately 5.9 percent of organic matter, or 59 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a brown mixed loam with about 4.7 percent of organic matter, according to the sample taken.

The subsoil probably varies more than the other strata. As sampled it contains about 2.4 percent of organic matter.

Management.—The type is not of great importance except for pasture. The essential factor in its management is good cultivation. Renewal by frequent overflows will maintain the fertility.

Deep Brown Silt Loam (1426)

Deep brown silt loam occurs only to the extent of 320 acres, and is located principally along the branches of the Mazon river in the northeastern part of the county.

The surface soil, 0 to 6⅔ inches, is a brown silt loam containing about 7 percent of organic matter.

The subsurface soil, 6⅔ to 20 inches, consists of a brown silt loam containing more or less sand. The organic-matter content is about 4.1 percent.

The subsoil varies from a brown silt loam to a brownish yellow silt loam. It contains about 1.8 percent of organic matter.

Management.—This type is well supplied with all elements of plant food and the main consideration in its management at present is good cultivation. As time goes on attention should be given to the need for limestone.

Deep Peat (1401)

Most of the deep peat is found in Townships 25 and 26 North, Range 8 East, where it occurs in rather deep depressions in the moraine. The total area of the type is 563 acres.

The surface soil, 0 to 6⅔ inches, is a black to brown peat containing a considerable percentage of shells in some local areas. These give a decidedly alkaline character to the soil.

The subsurface soil, 6⅔ to 20 inches, is a brown to black peat.

The subsoil is a brown to black peat, varying in the shallower areas to clayey material which may form a part of the subsoil.

Management.—Drainage is the first requirement of this type. Some parts have been drained and crops have been grown. The type, however, is low in

the element potassium, as is characteristic of peat, and an application of some form of potassium will probably be necessary before success can be obtained with corn and oats. For the results of field experiments on deep peat, see page 54 of the Supplement.

Medium Peat on Clay (1402)

The area mapped as medium peat on clay amounts to only 32 acres. Altho mapped as medium peat on clay, which would presume the peat to be not more than 30 inches deep, in reality the thickness of the peaty layer is extremely variable. In some spots the clay occurs within a few inches of the surface, while at other places a boring of 60 inches reveals nothing but peaty material. Evidently the sample taken for chemical analysis was collected from one of these spots of deeper peat, as the high contents of carbon and nitrogen would indicate.

Management.—In general this land should receive the same management as that suggested for deep peat (1401).

Muck on Marl (1413.6)

The only area of muck on marl in this county occurs in the southeast quarter of Section 32, Township 30 North, Range 7 East.

The surface soil, 0 to 6⅔ inches, is a black clayey material containing about 23 percent of organic matter.

The subsurface and subsoil are not uniform, but are made up of layers of marl alternating with clayey material. The samples examined contained about 5 percent of organic matter in the subsurface and 2 percent in the subsoil.

Management.—This type should be managed in the same way as black clay loam (–20).

(e) RESIDUAL SOILS

A residual soil is one which has not been transported thru the action of glacier, wind, or water, but is formed *in place* by the weathering of rocks and the accumulation of organic matter. Rock outcrops are also included in this group.

Stony Loam (098)

The only area of stony loam in the county is found in Section 1, Township 27 North, Range 5 East. This is a small area where the underlying rock comes close to the surface. The shallow soil partakes of the character of brown silt loam and is mixed with loose pieces of the partially weathered rock. At the highest part of the area the bare rock is exposed, and from this extreme the type merges gradually into typical brown silt loam. This outcrop affords a source of excellent limestone for soil improvement. A sample gave a purity test of nearly 99 percent of calcium carbonate equivalent.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to intelligently interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification here used.

The unit in the soil survey is the soil type, and each type possesses more or less definite characteristics. The line of separation between adjoining types is usually distinct, altho sometimes one type grades into another so gradually that it is very difficult to draw the line between them. In such exceptional cases, some slight variation in the location of soil-type boundaries is unavoidable.

In establishing soil types several factors must be taken into account. These are: (1) the geological origin of the soil, whether residual, cumulose, glacial, eolial, alluvial, or colluvial; (2) the topography, or lay of the land; (3) the native vegetation, as prairie grasses or forest; (4) the depth and the character of the surface, the subsurface, and the subsoil, as to the percentages of gravel sand, silt, clay, and organic matter which they contain, their porosity, granulation, friability, plasticity, color, etc.; (5) the natural drainage; (6) the agricultural value, based upon its natural productiveness; (7) the ultimate chemical composition and reaction.

Great Soil Areas in Illinois.—On the basis of the first of the above mentioned factors, namely, the geological origin, the state of Illinois has been divided into seventeen great soil areas with respect to their geological formation. The names of these areas are given in the following list along with their corresponding index numbers, the use of which is explained below. For the location of these geological areas, the reader is referred to the general map published in Bulletins 123 and 193.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* comprizing three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciations
300 *Lower Illinoisan glaciation,* covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* found in the older or Illinoisan glaciation
1400 *Late river-bottom and swamp lands,* those of the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan

Mechanical Composition of Soils.—The mechanical composition, or the texture, is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents:

Organic matter: undecomposed and partially decayed vegetable material
Inorganic matter: clay, silt, fine sand, sand, gravel, stones

Classes of Soils.—Based upon the relative proportion of the various constituents mentioned above, soils may be grouped into a number of well recognized classes. Following is a list of these classes, arranged according to their index numbers, the use of which is explained below:

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

Naming and Numbering Soil Types.—The naming of soil types has been the subject of much discussion, and practice varies considerably in this matter. In this soil survey of Illinois a system of classification and naming has been adopted which is based upon the various considerations presented in the preceding paragraphs.

After texture, one of the most striking characteristics of a soil is the color. Therefore, in the naming of soils in Illinois, a combination of color and texture, together with other descriptive terms when necessary, has been adopted so that the name in itself carries a definite description of a given soil type; as for example, "gray silt loam on tight clay," or "brown silt loam over gravel." The use of the prepositions *on* and *over* serves to indicate the presence of certain substrata. When the surface soil is underlain with material such as sand, gravel, or rock, the word *over* is used if this material lies at a depth greater than 30 inches; if it is less than 30 inches, the word *on* is used.

For further identification of soil types a system of numbering, resembling somewhat the Dewey library system, has been adopted whereby each soil type is assigned a certain number. This number indicates at once the geological origin of the soil as well as its physical description. The digits of the order of hundreds represent the geological area where the soil is found, beginning with 000, the residual, followed by 100, the unglaciated, and the rest of the series in the order of the enumeration presented in the paragraph above headed *Great Soil Areas in Illinois*. The digits of the orders of units and tens represent the various kinds of soil such as are enumerated above in the list of soil classes. Certain modifications are designated in this system by a figure placed at the right of the decimal point. To illustrate the working of this numbering system, suppose a soil type bears the number 726.5. The number 7 indicates that this soil occurs in the Iowan glaciation, the 26 that it is a brown silt loam, and the .5 that rock

is found less than 30 inches below the surface. These numbers are especially useful in designating small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports.

SOIL SURVEY METHODS

Mapping the Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. In order that the survey be thoroly trustworthy it is necessary that careful, well-trained men be employed to do the mapping. The work is prosecuted to the best advantage by working in parties of from two to four. Only such men are placed in charge of these parties as are thoroly experienced in the work and have shown themselves to be especially well qualified in training and ability.

The men must be able to keep their location exactly and to recognize the different soil types, with their principal variations and limits, and they must show these upon the maps correctly. A definite system is employed in checking up this work. As an illustration, one man will survey and map a strip 80 rods or 160 rods wide and any convenient length, while his associate will work independently on another strip adjoining this area, and if the work is correctly done the soil-type boundaries will match up on the line between the two strips.

An accurate base map for field use is absolutely necessary for soil mapping. The base maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as a basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil-type boundaries, together with the streams, roads, railroads, canals, and town sites are placed in their proper locations upon the map while the mapper is on the area. Each section, or square mile, is divided into 40-acre plots on the map, and the surveyor must inspect every ten acres and determine the type or types of soil thereon. The different types are indicated on the map by different colors, pencils for this purpose being carried in the field.

A small auger 40 inches long forms for each man an invaluable tool with which he can quickly secure samples of the different strata for inspection. An extension for making the auger 80 inches long is taken by each party, so that any peculiarity of the deeper subsoil layers may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by a speedometer or by some other measuring device, while distances in the field away from the roads are determined by pacing, an art in which the men become expert by practice. The soil boundaries can thus be located with as high a degree of accuracy as can be indicated by pencil on the scale of one inch to the mile.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. For this purpose usually three strata are sampled; namely, the surface (0 to 6⅔ inches), the subsurface (6⅔ to 20 inches), and the subsoil

(20 to 40 inches). These strata correspond approximately, in the common kinds of soil, to 2,000,000 pounds of dry soil per acre in the surface layer, and to two times and three times this quantity in the subsurface and the subsoil, respectively. This is, of course, a purely arbitrary division, very useful in arriving at a knowledge of the quantity and the distribution of plant food in the soil, but it should be noted that these strata do not necessarily coincide with the natural strata as they actually exist in the soil, and which are referred to in describing the soil types.

By this system of sampling we have represented separately three zones for plant feeding. The surface layer includes at least as much soil as is ordinarily turned with the plow. This is the part with which the farm manure, limestone, phosphate, or other fertilizer applied in soil improvement is incorporated, and which must be depended upon in large part to furnish the necessary plant food for the production of crops. A rich subsoil has little or no value if it lies beneath a worn-out surface, but if the fertility of the surface soil is maintained at a high point, then the strong vigorous plants will have power to secure more plant food from the subsurface and subsoil.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. Even tho plowed alike and at the same time, prepared the same way, planted the same day with the same kind of seed, and cultivated alike, watered by the same rains and warmed by the same sun, nevertheless the best acre may produce twice as large a crop as the poorest acre on the same farm, if not, indeed, in the same field; and the fact should be repeated and emphasized that with the normal rainfall of Illinois the productive power of the land depends primarily upon the stock of plant food contained in the soil and upon the rate at which it is liberated, just as the success of the merchant depends primarily upon his stock of goods and the rapidity of sales. In both cases the stock of any commodity must be increased or renewed whenever the supply of such commodity becomes so depleted as to limit the success of the business, whether on the farm or in the store.

CROP REQUIREMENTS

Ten different elements of plant food are essential for the growth and formation of every plant. These elements are: *carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, magnesium, calcium, and iron;* and they are represented by the chemical symbols: C, O, H, N, P, S, K, Mg, Ca, and Fe. Some seasons in central Illinois are sufficiently favorable to allow the production of at least 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. When such crops, growing under favorable climatic and cultural conditions and uninjured by disease or insect pests, are not produced the failure is due to unfavorable soil condition, which may result from poor drainage, poor physical condition, or from an actual deficiency of plant food.

Table A shows the plant-food requirements of some of our most common field crops with respect to the seven elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a

Table A.—Plant Food in Wheat, Corn, Oats, and Clover

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain......	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat, straw.....	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain.......	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover.......	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs........	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain.......	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw........	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed.......	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay.......	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00

ton, as the case may be. From these data the amount of any element removed from an acre of land by a crop of a given yield can easily be computed.

It needs no argument to show that the continuous removal of such quantities of plant food without provision for their replacement must result sooner or later in soil depletion.

PLANT-FOOD SUPPLY

Of the ten elements of plant food, three (*carbon, oxygen,* and *hydrogen*) are secured from air and water, and seven from the soil. *Nitrogen,* one of these seven elements obtained from the soil by all plants, may also be secured from the

Table B.—Plant-Food Elements in Manure, Rough Feeds, and Fertilizers

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure............................	10	2	8
Corn stover....................................	16	2	17
Oat straw......................................	12	2	21
Wheat straw....................................	10	2	18
Clover hay.....................................	40	5	30
Cowpea hay.....................................	43	5	33
Alfalfa hay....................................	50	4	24
Sweet clover (water-free basis)[1].............	80	8	28
Dried blood....................................	280	...	...
Sodium nitrate.................................	310	...	...
Ammonium sulfate...............................	400	...	...
Raw bone meal..................................	80	180	...
Steamed bone meal..............................	20	250	...
Raw rock phosphate.............................	...	250	...
Acid phosphate.................................	...	125	...
Potassium chlorid..............................	...	...	850
Potassium sulfate..............................	...	...	850
Kainit...	...	...	200
Wood ashes[2]..................................	...	10	100

[1]Young second year's growth ready to plow under as green manure.
[2]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

air by one class of plants (legumes), in case the amount liberated from the soil is insufficient; but even these plants (which include only the clovers, peas, beans, vetches, and alfalfa among our common agricultural plants) are dependent upon the soil for the other six elements (*phosphorus, potassium, magnesium, calcium, iron,* and *sulfur*), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to nearly 33,000 pounds. In like manner the phosphorus content varies from about 420 to 4,900 pounds, the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table B is presented for the purpose of furnishing information regarding the quantity of plant food contained in some of the materials most commonly used as sources of plant-food supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of fertility actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such plant foods as calcium and phosphorus, converting them into available forms of food for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral foods are liberated for the benefit of the cereal crops which follow in the rotation, and which are less independent feeders. Moreover, as an effect of the deep rooting habit of these legumes, large quantities of mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and thus encourages the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the insoluble and unavailable organic nitrogen into soluble and available nitrate nitrogen. At the

same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium, and also to dissolve the insoluble phosphate and limestone which may be applied in low-priced forms. Thus, in the conversion of sufficient organic nitrogen into nitrate nitrogen for a 100-bushel crop of corn, the nitrous acid formed is alone sufficient to convert seven times as much insoluble tricalcium phosphate into soluble monocalcium phosphate as would be required to supply the phosphorus for the same crop.

Organic Matter and Biological Action.—Organic matter may be supplied by animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, somewhat more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds roughly to 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant food than the 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the *ratio of carbon to nitrogen.* Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing soluble phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant food by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant food is concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides the plant food calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by preventing the growth of certain fungus diseases, such as corn root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement.

Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands. Remarkable success has been experienced with limestone used in conjunction with sweet clover in the reclamation of abandoned hill land which had been ruined thru erosion.

Amounts to Apply.—If the soil is acid, usually at least 2 tons per acre of ground limestone should be applied as an initial treatment. Continue to apply limestone from time to time according to the requirement of the soil as indicated by the tests described below, or until the most favorable conditions are established for the growth of legumes. In case the magnesium content of the soil is low, magnesian limestone ($CaCO_3MgCO_3$), which contains both calcium and magnesium and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone ($CaCO_3$) may be used. On strongly acid soils, or on land being prepared for alfalfa, 4 or 5 tons per acre of ground limestone may well be used for the first application.

How to Ascertain the Need for Limestone.—The need of a soil for limestone may be ascertained by applying the following test for soil acidity. Along with the acidity test, a test for the presence of carbonates should be made. It should be understood that a positive test for carbonates does not guarantee the absence of acid; for it may happen, especially when the soil is near the neutral point, that positive tests for both acidity and carbonates are obtained. This condition is explained by the assumption that solid particles of calcium or magnesium carbonates form centers of alkalinity within a soil that is generally acid. Because of this fact any test made of a given soil ought to be repeated if it is to be thoroly reliable. It is also desirable to test samples from different depths. Following are the directions for making these tests:

The Potassium Thiocyanate Test for Acidity. This test for soil acidity is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol (not denatured). When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the test. In testing, therefore, the soil should not be wetter than it would be when in good tillable condition. The conditions for a prompt reaction require a temperature that is comfortably warm.

The Hydrochloric Acid Test for Carbonates. Make a shallow cup of a ball of soil and pour into it a few drops of concentrated hydrochloric acid. If carbonates are present they are decomposed with the liberation of carbon dioxid, which appears as gas bubbles, producing foaming or effervescence. With much carbonate present the action is lively, but with mere traces of it the bubbles are given off slowly. If no carbonate, or very little, is indicated by the test, then it is advisable to apply limestone.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for agricultural uses. *These are the chemical and the biological fixation of the atmospheric nitrogen.* Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of those legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for feed and seed as well as for nitrate production, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen, the possibilities of which now represent numerous compounds, will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes.

For easy figuring it may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpeas contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain

crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of a soil varies according to its origin and the kind of farming practiced. Even virgin soils are found that are deficient in phosphorus.

It should always be borne in mind in connection with the application of phosphorus to the land that the addition of phosphorus, or of any other fertilizing substance, to the soil can exert no benefit until the need of it has become a limiting factor of production. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different materials containing phosphorus which are applied to land as fertilizer. The more important of these are bone meal, acid phosphate, natural raw rock phosphate, and basic slag. Obviously that carrier of phosphorus which gives the most economical returns, as considered from all standpoints, is the most suitable one to use. Altho this matter has been the subject of much discussion and investigation the question still remains unsettled. Probably there is no single carrier of phosphorus that will prove to be the most economical one to use under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

Bone meal, prepared from the bones of animals, appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the phosphorus, a considerable percentage of nitrogen which adds a useless expense if the material is purchased for the sake of the phosphorus. As a source of phosphorus, steamed bone meal is preferable to raw bone meal. Steamed bone meal is prepared by extracting most of the nitrogenous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate containing about 10 to 12 percent of the element phosphorus.

Acid phosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. Acid phosphate also contains besides phosphorus, sulfur, which is another plant-food element. The phosphorus in acid phosphate is more readily available for absorption by plants than that of raw rock phosphate. Acid phosphate of good quality should contain 6 percent or more of the element phosphorus.

Rock phosphate, sometimes called floats, is a mineral substance found in vast deposits in certain regions. The phosphorus in this mineral exists chemically as tri-calcium phosphate and a good grade of the rock should contain 12½ percent, or more, of the element phosphorus. The rock should be ground to a powder, fine enough to pass thru a 100-mesh sieve, or even finer.

The relative cheapness of raw rock phosphate, as compared with the treated or acidulated material, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in this form than in the form of acid phosphate, the ratio being, under the market conditions of the past several years, about 4 to 1. That is to say, under these market conditions, a dollar will purchase about four times as much of the element phosphorus in the form of rock phosphate as in the form of acid phosphate, which is an important consideration if one is interested in building up a phosphorus reserve in the soil. As explained above, more very carefully conducted comparisons on various soil types under various cropping systems are needed before definite statements can be given as to which form of phosphate is most economical to use in all situations.

Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag phosphate is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore it tends to influence to some extent the soil reaction.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using acid phosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, in which clay and silt form a considerable part of the constituency, are well stocked with potassium, altho it exists largely in insoluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be supplied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of common soils are concerned, that the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part perhaps because the potassium removed in the crops is mostly returned in the manure if properly cared for, and perhaps in larger part because the decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no plant food of value.

In considering the conservation of potassium on the farm it should be remembered that in average live-stock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in live-stock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by the actual crop requirements for plant food, magnesium and calcium are more limited in some Illinois soils than potassium. But with these elements we must also consider the loss by leaching.

Doctor Edward Bartow and associates, of the Illinois State Water Survey, have shown that as an average of 90 analyses of Illinois well-waters drawn chiefly from glacial sands, gravels, or till, 3 million pounds of water (about the average annual drainage per acre for Illinois) contained 11 pounds of potassium, 130 of magnesium, and 330 of calcium. These figures are very significant, and it may be stated that if the plowed soil is well supplied with the carbonates of magnesium and calcium, then a very considerable proportion of these amounts will be leached from that stratum. Thus the loss of calcium from the plowed soil of an acre at Rothamsted, England, where the soil contains plenty of limestone, has averaged more than 300 pounds a year as determined by analyzing the soil in 1865 and again in 1905. And practically the same amount of calcium was found by analyzing the Rothamsted drainage waters.

The annual loss of limestone from the soil depends, of course, upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of carbonates from the soil, it

is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests described on pages 35 and 36, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

It is of interest to note that thirty crops of clover of 4 tons each would require 3,510 pounds of calcium, while the most common prairie land of southern Illinois contains only 3,420 pounds of total calcium in the plowed soil of an acre. Thus limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply to conditions in Illinois.

Physical Improvement of Soils

In the management of most soil types, one very important thing, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is being destroyed during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, corn stalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and corn stalks should be turned under, and not burned. Probably no form of organic matter acts more beneficially in producing good tilth than corn stalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of corn stalks is one and one-half times that of a ton of manure, and a ton of dry corn stalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the corn stalks during the winter and often rather late in the spring after the frost is out of the ground. This tramping by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The effect becomes worse if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including a liberal use of legumes, in order to increase the organic matter of the soil either by plowing under the legume crops and other crop residues (straw and corn stalks), or by using for feed and bedding practically all the crops raised and returning the manure to the land with the least possible loss. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations, applicable to the corn belt, which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover), or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in live-stock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be seeded four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Wheat (with clover)
Second year —Corn
Third year —Oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields Representing the More Important Types of Soil Occurring in Livingston County)

In the earlier reports of this series it was the practice to incorporate in the body of the report the results of certain experiment fields, for the purpose of illustrating the possibilities of improving the soil of various types. The information carried by such data must, naturally, be considered more or less tentative. As the fields grow older new facts develop, which in some instances may call for the modification of former recommendations. It has therefore seemed desirable to separate this experiment field data from the more permanent information of the soil survey, and embody the same in the form of a supplement to the soil report proper, thus providing a convenient arrangement for possible future revisions as further data accumulate.

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the summarized results from certain of these fields which are representative of the types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement

These fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, live-stock farming and grain farming.

In the live-stock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in form of plant manures, including all the plant residues produced, such as corn stalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It is the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the live-stock system.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations, and on most of the fields provision is made so that every crop in the rotation is represented every year. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing

on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a rather definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, the equivalent of 200 pounds of kainit. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

BROWN SILT LOAM

Several experiment fields have been conducted on brown silt loam soil at various locations in Illinois. Those located at the University have been in operation the longest and they serve well to illustrate the principles involved in the maintenance and improvement of this type of soil.

The Morrow Plots

It happens that the oldest soil experiment field in the United States is located on typical brown silt loam of the early Wisconsin glaciation, on the campus of the University of Illinois. This field was started in 1879 by George E. Morrow, who for many years was Professor of Agriculture, and these plots are known as the Morrow plots.

The Morrow series now consists of three plots divided into halves and the halves are subdivided into quarters. On one plot corn is grown continuously; on the second corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904, receiving standard applications of farm manure with cover crops grown in the one-crop and two-crop systems. Phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. At the same time the rate of subsequent application of both forms of phosphorus was reduced to one-fourth the quantity, or to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per year. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre with the intention of standardizing the application to the rate of 1,000 pounds of limestone per acre per year.

Table 1 gives the yearly records of the crop yields, and Table 2 presents the same in summarized form.

FIG. 1.—CORN ON THE MORROW PLOTS IN 1910

TABLE 1.—URBANA FIELD, MORROW PLOTS: BROWN SILT LOAM; PRAIRIE; EARLY WISCONSIN GLACIATION

Crop Yields in Soil Experiments—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
		Corn	Corn	Oats	Corn	Oats	Clover
1879–87	None........	....	....	....	....	....	....
1888	None........	54.3	49.5	....	....	48.6	....
1889	None........	43.2	....	37.4	....	....	(4.04)
1890	None........	48.7	54.3	....	....	....	(1.51)
1891	None........	28.6	33.2	....	....	....	(1.46)
1892	None........	33.1	....	37.2	70.2	....	....
1893	None........	21.7	29.6	....	34.1	....	....
1894	None........	34.8	....	57.2	....	65.1	....
1895	None........	42.2	41.6	....	....	22.2	....
1896	None........	62.3	....	34.5	....	....	....
1897	None........	40.1	47.0	....	....	....	....
1898	None........	18.1	....	....	....	....	....
1899	None........	50.1	44.4	....	53.5	....	....
1900	None........	48.0	....	41.5	....	....	....
1901	None........	23.7	33.7	....	34.3	....	....
1902	None........	60.2	....	56.3	....	54.6	....
1903	None........	26.0	35.9	....	....	....	(1.11)
1904	None........	21.5	....	17.5	55.3	....	....
1904	MLP........	17.1	....	25.3	72.7	....	....
1905	None........	24.8	50.0	....	....	42.3	....
1905	MLP........	31.4	44.9	....	....	50.6	....
1906	None........	27.1	....	34.7	....	....	(1.42)[1]
1906	MLP........	35.8	....	52.4	....	....	(1.74)[1]
1907	None........	29.0	47.8	....	80.5	....	....
1907	MLP........	48.7	87.6	....	93.6	....	....
1908	None........	13.4	....	32.9	....	40.0	....
1908	MLP........	28.0	....	45.0	....	44.4	....
1909	None........	26.6	33.0	....	....	....	(.65)[2]
1909	MLP........	31.6	64.8	....	....	....	(1.73)[3]
1910	None........	35.9	....	33.8	58.6	....	....
1910	MLP........	54.6	....	59.4	83.3	....	....
1911	None........	21.9	28.6	....	....	20.6	....
1911	MLP........	31.5	46.3	....	....	38.0	....
1912	None........	43.2	....	55.0	....	....	16.3[1]
1912	MLP........	64.2	....	81.0	....	....	20.0[1]
1913	None........	19.4	29.2	....	33.8	....	....
1913	MLP........	32.0	25.0	....	47.8	....	....
1914	None........	31.6	....	33.6	....	39.6	....
1914	MLP........	39.4	....	58.2	....	60.4	....
1915	None........	40.0	49.0	....	....	....	24.2[1]
1915	MLP........	66.0	81.2	....	....	....	27.1[1]
1916	None........	11.2	....	37.5	27.8	....	....
1916	MLP........	10.8	....	64.7	40.6	....	....
1917	None........	40.0	48.4	....	....	68.4	....
1917	MLP........	78.0	81.4	....	....	86.9	....
1918	None........	13.6	....	27.2	....	....	(2.58)
1918	MLP........	32.6	....	59.3	....	....	(4.04)
1919	None........	24.0	30.8	....	52.2	....	....
1919	MLP........	43.4	66.2	....	70.8	....	....
1920	None........	28.2	....	37.2	....	52.2	....
1920	MLP........	54.4	....	51.6	....	69.7	....
1921	None........	19.8	30.6	....	....	....	(.26)[4]
1921	MLP........	42.2	68.4	....	....	....	(1.33)[5]

[1]Soybeans.
[2]In addition to the hay, .64 bushel of seed was harvested.
[3]In addition to the hay, 1.17 bushels of seed were harvested
[4]In addition to the hay, .53 bushel of seed was harvested.
[5]In addition to the hay, .85 bushel of seed was harvested.

TABLE 2.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY
Average Annual Yields—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover
		16 crops	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
1888 to 1903	None........	39.7	41.0	44.0	48.0	47.6	(2.03)
		18 crops	*9 crops*	*9 crops*	*6 crops*	*6 crops*	*4 crops*
1904 to 1921	None........	26.2	38.6	34.4	51.4	43.9	(1.23)[1]
	MLP........	41.2	62.9	55.2	68.1	58.3	(2.21)[1]

[1]One crop of soybean hay.

Summarizing the data from these Morrow plots into two periods with the second period beginning in 1904 when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oats production, while the averages for the three-year system show an increase in corn yield and decreases in oats and clover. Unfortunately the numbers of crops included in these last averages are too small to warrant positive conclusions.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

The Davenport Plots

Another set of plots on the University campus at Urbana, forming a more extensive series than the Morrow plots, but of more recent origin, are the Davenport plots. Here each crop in the rotation is represented every year. These plots were laid out in 1895, but special soil treatment was not begun until 1901. They now comprize five series of ten plots each, and each series constitutes a "field" in a crop rotation system.

From 1901 to 1911 three of the series were in a three-year rotation system of corn, oats, and clover, while the remaining two series rotated in corn and oats. In 1911 these two systems were combined into a five-series field, with a crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field. The alfalfa occupies one series during a rotation of the other four crops, shifting to another series in the fifth year, thus completing the cycle of all series in twenty-five years.

The soil treatment applied to these plots has been as follows:

Legume cover crops were seeded in the corn at the last cultivation on Plots 2, 4, 6, and 8, from 1902 to 1907, but the growth was small and the effect, if any, was to decrease the returns from the regular crops. Crop residues (**R**) have been returned to these same plots since 1907. These consist of stalks and straw, and all legumes except alfalfa hay and the seed of clover and soybeans. Beginning in 1918 a modification of the practice was made in that one cutting of the red clover crop is harvested as hay. In conjunction with these residues a catch crop of sweet clover grown with the wheat is plowed under.

TABLE 3.—URBANA FIELD, DAVENPORT PLOTS: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Ten-Year Average Annual Yields—Bushels or (tons) per acre
1911–1920

Serial plot No.	Soil treatment applied	Corn	Oats	Wheat	Clover 5 crops	Soybeans 5 crops	Alfalfa
1	0.............	55.6	50.5	26.0	(2.42)	(1.47)	(2.43)
2	R.............	57.1	52.3	28.7	1.47[1]	19.8	(2.46)
3	M.............	66.3	61.9	28.2	(2.56)	(1.62)	(2.52)
4	RL............	64.8	55.6	31.4	1.61[1]	20.3	(2.72)
5	ML............	69.6	64.1	32.8	(2.90)	(1.67)	(3.03)
6	RLP...........	71.5	69.8	43.0	2.29[1]	23.5	(3.69)
7	MLP...........	73.0	68.6	40.0	(3.52)	(1.97)	(3.76)
8	RLPK.........	70.9	72.5	40.7	1.79[1]	25.5	(3.77)
9	MLPK.........	70.2	72.0	39.2	(3.40)	(2.20)	(3.73)
10	Mx5LPx5.......	65.9	71.4	40.6	(3.31)	(2.22)	(3.77)

[1]In addition to the clover seed, a crop of hay was harvested one year on Plots 2, 4, 6, and 8, yielding 2.38, 2.20, 2.54, and 2.39 tons, respectively.

Manure (**M**) was applied preceding corn, at the rate of 2 tons per acre per year in 1905, 1906, and 1907; subsequently as many tons have been applied as there have been tons of air-dry produce harvested from the respective plots.

Lime (**L**) was applied on Plots 4 to 10 at the rate per acre of 250 pounds of air-slaked lime in 1902, and 600 pounds of limestone in 1903. No further application was made until 1911, when the system of cropping was changed. Since that time applications of limestone have been made at the rate of one-half ton per acre per year.

Phosphorus (**P**) was applied on Plots 6 to 9 at the rate of 25 pounds per acre per annum in 200 pounds of steamed bone meal; but beginning with 1908 rock phosphate at the rate of 600 pounds per acre per annum was substituted for the bone meal on one-half of each of these plots. These applications continued until 1918 when adjustments were begun, first to make the rate of application of rock phosphate four times that of the bone meal, and finally to reduce the amounts of these materials to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per annum. The usual practice has been to apply and plow under at one time all phosphorus and potassium required for the rotation.

Potassium (**K** = kalium) has been applied on Plots 8 and 9 in connection with the bone meal and rock phosphate, at the yearly rate of 42 pounds per acre, and mainly as potassium sulfate.

On Plot 10 about five times as much manure and phosphorus are applied as on the other plots, but this "extra heavy" treatment was not begun until 1906, only the usual amounts of lime, phosphorus, and potassium having been applied in previous years. The purpose in making these heavy applications is to try to determine the climatic possibilities in crop yields by removing the limitations of inadequate amounts of the elements of plant food.

It will be observed that the applications described above provide for the two rather distinct systems of farming already described. *The grain system,* in which animal manure is not produced and where the organic matter is provided by the direct return to the soil of all crop residues along with legumes,

is exemplified in Plots 2, 4, 6, and 8; and the *live-stock system,* in which farm manure is utilized for soil enrichment, is represented in Plots 3, 5, 7, and 9.

Table 3 shows a summary of the results obtained on the Davenport plots beginning with the year 1911, when the present cropping system was introduced.

When used in conjunction with phosphorus the crop residues and the manure appear about equally effective; but where phosphorus is not applied, the manure has been decidedly more effective, under the conditions of the experiment. It should be observed, however, in this connection, that the plowing under of clover is a very essential feature of the residues system, and that, as a matter of fact, there were five clover failures, when soybeans were substituted, during the ten years. Perhaps with a more reliable biennial legume than red clover, the results would have been more favorable for this system.

By comparing Plots 2 and 3 with Plots 4 and 5, it is found that limestone has had a beneficial effect on all crops. What the financial profit amounts to depends obviously upon the market value of the crops and the cost of the limestone.

Comparing Plots 4 and 5 with Plots 6 and 7, respectively, there is found in all cases an increase in crop yield as a result of adding phosphorus. The effect on wheat is especially pronounced. Where limestone and phosphorus are applied in addition to the crop residues, an increase of 17 bushels of wheat, over the yield of the untreated land, has been obtained as a ten-year average.

Manure
Yield: 1.43 tons per acre

Manure, limestone, phosphorus
Yield: 2.90 tons per acre

FIG. 2.—CLOVER ON THE DAVENPORT PLOTS IN 1913

The effect of adding potassium to the treatment is of much interest. Plots 8 and 9 are the same as Plots 6 and 7, respectively, except that potassium has been applied to the former. On the whole, no significant benefit is shown from the addition of potassium.

No benefit appears as the result of the extra-heavy applications of manure and phosphorus on Plot 10. In fact the corn yields are noticeably less here than on the plots receiving the normal applications of these materials.

The University South Farm

On the University South Farm, at Urbana, several series of plots devoted primarily to variety testing and other crop-production experiments are so laid out as to show the effects of certain soil treatments that have been applied. Several different systems of crop rotation are employed and the crops are so handled as to exemplify the two general systems of farming, grain and live-stock.

The summarized results presented in Table 4 represent three different systems of cropping. The first, designated as the Southwest rotation, is to be regarded as a good rotation for general practice, on this type of soil, under Illinois conditions. This is a four-field rotation of wheat, corn, oats, and clover.

Residues plowed under
Yield: 35.2 bushels per acre

Residues and rock phosphate
Yield: 50.1 bushels per acre

FIG. 3.—WHEAT ON THE UNIVERSITY SOUTH FARM IN 1911

TABLE 4.—URBANA FIELD, SOUTH FARM: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Southwest Rotation: Series 100, 200, 400[1]: Wheat, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 9 crops	Oats[3] 9 crops	Wheat[3] 8 crops	Clover[4] 3 crops	Soybeans 7 crops
RP	62.3	51.9	41.0	1.05	17.3[5]
R	51.9	46.5	26.9	1.38	16.2[5]
M	59.7	50.2	29.1	(2.28)	(1.25)
MP	64.3	55.4	43.1	(2.86)	(1.51)
RLP	60.5	57.2	41.8	.64	16.4[5]
R	49.7	49.6	25.8	.83	14.7[5]
M	55.5	54.1	27.8	(1.71)	(1.28)
MLP	64.1	59.6	43.9	(1.77)	(1.58)

North-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Oats 9 crops	Clover 5 crops	Soybeans 4 crops
RP	56.7	51.1	56.1	.54	16.9
R	51.7	45.2	52.0	.50	16.0
M	54.9	46.7	52.1	(2.29)	(1.60)
MP	56.5	53.4	56.9	(2.73)	(1.74)

South-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Corn, Soybeans

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Corn 3d year 9 crops		Soybeans 9 crops
RP	51.9	44.0	41.3		20.0
R	45.5	39.9	35.2		19.2
M	50.1	42.1	33.5		(1.59)
MP	54.5	46.7	42.0		(1.66)

[1]Results from Series 300 and 800 are omitted on account of variation in soil type.
[2]Soybeans when clover fails.
[3]Only seven crops with limestone.
[4]Only one crop with limestone.
[5]Average of five crops.
[6]All phosphorus plots received ½ ton per acre of limestone in 1903.

The second, or North-Central rotation, consisting of corn, corn, oats, and clover, represents a system very commonly practiced; and the third or South-Central rotation, consisting of corn, corn, corn, and soybeans, must be considered as a poor rotation from the standpoint of maintaining the productiveness of the land.

On the whole, residues alone have not returned yields quite so high as those produced by the manure treatment; but, as remarked above in the discussion of the Davenport plots, the residues system has probably been at a disadvantage thru frequent clover failures. On the North-Central rotation, where conditions seem to have been more favorable for clover, there is very little difference between the effect of manure and of residues.

Limestone, which has been used in the southwest rotation, appears to have produced no increase of consequence to any of the crops except oats. The comparison may be somewhat impaired, however, by a possible residual effect of the small application of limestone made in 1903 to all the phosphorus plots.

The results obtained from the use of phosphorus are of especial interest because this element has been applied to these plots in all three rotations solely in the form of raw rock phosphate. The figures in almost every case show an increase in yield where the phosphorus has been applied, and in most cases this increase is very pronounced. The wheat is especially responsive to phosphorus.

The records furnish some interesting comparisons of corn yields produced under different systems of cropping. Table 5 gives a general summary of the corn yields only, in which the results from the residues and manure treatments are averaged together as "organic manures." The highest annual acre-yields are found where corn occurs but once in a rotation. Where corn is grown twice in succession, the annual acre-yields are less; and where corn occurs three times, there is a further reduction. Also, the first crop of corn within a rotation produces more than the second, and the second crop yields more than the third. These are useful facts for consideration in connection with problems of general farm management.

TABLE 5.—COMPARING PRODUCTION OF CORN IN THREE DIFFERENT ROTATION SYSTEMS
ACRE YIELDS FROM PLOTS ON THE UNIVERSITY SOUTH FARM

Twelve-Year Average (1908–1919)—Bushels per acre

Rotation	Wheat-corn-oats-legume[1]	Corn-corn-oats-legume[2]		Corn-corn-corn-legume[3]		
Treatment	Corn	1st Corn	2d Corn	1st Corn	2d Corn	3d Corn
Organic manures	55.8	53.3	46.0	47.8	41.0	34.3
Organic manures, phosphorus	63.2	56.6	52.3	53.2	45.3	41.6

[1]Clover 3 crops, and soybeans 7 crops.
[2]Clover 5 crops, and soybeans 5 crops.
[3]Soybeans 9 crops.

The Joliet and Minonk Fields

Data from two fields on brown silt loam located in the vicinity of Livingston county are introduced here. One of these fields is located near Joliet in Will county and the other at Minonk in Woodford county. The lay-out of plots and the crop rotations on the two fields are alike. The summarized results of the three grain crops, corn, oats, and wheat, are given in Table 6, the yields for the legume crops being for the present purpose disregarded.

In considering the results from these two fields it should be pointed out that they represent opposite phases of the brown silt loam type, the Joliet field being situated on a rather light phase while the Minonk field lies on a very heavy phase, approaching, in fact, black clay loam in character. Moreover, the crop yields on the untreated land (Plots 1, 5, and 10) indicate that the Minonk field is on a considerably higher plane of natural productiveness than the Joliet field, which fact may account to a large extent for some of the discrepancies in response to soil treatment.

In looking over the results presented in Table 6, one of the first points of interest is the effect of farm manure. On both of these fields manure has produced a decided increase in yield of corn, and with the exception of the oats at Minonk, there has been a beneficial effect on all crops. This suggests the importance of carefully saving and regularly applying all available animal manure.

TABLE 6.—JOLIET and MINONK FIELDS: BROWN SILT LOAM, PRAIRIE; JOLIET, LATE WISCONSIN GLACIATION; MINONK, EARLY WISCONSIN GLACIATION

Average Annual Grain Yields—Bushels per acre

Soil treatment applied	Joliet Field (1915-1922)			Minonk Field (1912-1922)		
	Corn 10 crops	Oats 7 crops	Wheat 5 crops	Corn 11 crops	Oats 10 crops	Wheat 8 crops
0	28.1	61.1	25.4	51.4	59.9	34.1
M	36.3	66.8	30.3	60.2	59.8	36.9
ML	40.2	68.0	35.2	61.7	60.3	34.4
MLP	42.9	72.8	41.9	62.5	59.3	36.1
0	29.2	62.0	25.1	51.7	56.3	34.2
R	33.5	62.4	27.9	59.3	60.9	35.4
RL	37.4	63.2	28.9	62.1	61.0	32.6
RLP	41.7	67.8	38.7	61.4	63.2	34.3
RLPK	46.4	70.6	41.1	60.2	63.1	33.2
0	31.9	62.9	26.5	48.0	57.3	28.2
Increases—Bushels per acre						
M over 0	8.2	5.7	4.9	8.8	−0.1	2.8
ML over M	3.9	1.2	4.9	1.5	0.5	−2.2
MLP over ML	2.7	4.8	6.7	0.8	−1.0	1.7
R over 0	4.3	0.4	2.8	7.6	4.6	1.2
RL over R	3.9	0.8	1.0	2.8	0.1	−2.8
RLP over RL	4.3	4.6	9.8	−0.7	2.2	1.7
RLPK over RLP	4.7	2.8	2.4	−1.2	−0.1	−1.1

Residues, alone, has likewise given a substantial increase in corn, altho the response by the other crops is not so marked.

Limestone has given variable results. On the Joliet field all crops have shown some benefit from the use of limestone. On the other hand, the increases due to limestone on the Minonk field are not significant, some of the effects even appearing as negative. The behavior of limestone on these two fields is characteristic for the brown silt loam of this region. Some of the land is in need of limestone and some of it is not. The limestone requirement, therefore, cannot be covered by a general prescription; rather, it is a matter which must be determined for each individual farm or even for each individual field.

Rock phosphate has given very favorable returns as measured by increases in crop yields on the Joliet field. On the Minonk field, however, the opposite is true. The small differences appearing as the effect of the treatment are probably not significant, being within the range of the experimental error due to the natural plot variation. This variation in response to rock phosphate on brown silt loam is likewise characteristic. On some experiment fields very pronounced and consistent gains have attended the use of this material. On certain other fields, however, where it has been applied in the same amounts and in similar manner, it has not produced sufficient increase to cover the cost. It remains for further investigation to explain this discrepancy.

The potassium fertilizer on the Joliet field has apparently produced a profitable gain, but on the Minonk field all of the "increases" are negative. There is usually little or no response in the grain crops to potassium treatment on brown silt loam.

Deep Peat

As representing the deep peat type of soil, the results are introduced from an experiment field conducted at Manito in Mason county during the years 1902 to 1905 inclusive.

The results of the four years' tests, as given in Table 8, are in complete harmony with the information furnished by the chemical composition of peat soil. Where potassium was applied, the yield was from three to four times as large as where nothing was applied. Where approximately equal money values of kainit and potassium chlorid were applied, slightly greater yields were obtained with the potassium chlorid, which, however, supplied about one-third more potassium than the kainit. On the other hand, either material furnished more potassium than was required by the crops produced.

The use of 700 pounds of sodium chlorid (common salt) produced no appreciable increase over the best untreated plots, indicating that where potassium is itself actually deficient, salts of other elements cannot take its place.

Applications of 2 tons per acre of ground limestone produced no increase in the corn crops, either when applied alone or in combination with kainit, either the first year or the second.

Reducing the application of kainit from 600 to 300 pounds for each two-year period reduced the yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainit (Plot 9) furnished 60 pounds of potassium for the four years, an amount sufficient for 84 bushels of corn (grain and stalks). Attention is called to the fact that this is practically the difference between the yield of Plot 9 (125.9 bushels) and the yield obtained from Plot 2 (42.9 bushels), the poorest untreated plot.

TABLE 7.—MANITO FIELD: DEEP PEAT

Corn Yields—Bushels

Plot No.	Soil treatment for 1902	Corn 1902	Corn 1903	Soil treatment for 1904	Corn 1904	Corn 1905	Four crops
1	None	10.9	8.1	None	17.0	12.0	48.0
2	None	10.4	10.4	Limestone, 4000 lbs.	12.0	10.1	42.9
3	Kainit, 600 lbs.	30.4	32.4	Limestone, 4000 lbs. Kainit, 1200 lbs.	49.6	47.3	159.7
4	Kainit, 600 lbs. Acidulated bone, 350 lb.	30.3	33.3	Kainit, 1200 lbs. Steamed bone, 395 lbs.	53.5	47.6	164.7
5	Potassium chlorid, 200 lbs.	31.2	33.9	Potassium chlorid, 400 lbs.	48.5	52.7	166.3
6	Sodium chlorid, 700 lbs.	11.1	13.1	None	24.0	22.1	70.3
7	Sodium chlorid, 700 lbs.	13.3	14.5	Kainit, 1200 lbs.	44.5	47.3	......
8	Kainit, 600 lbs.	36.8	37.7	Kainit, 600 lbs.	44.0	46.0	164.5
9	Kainit, 300 lbs.	26.4	25.1	Kainit, 300 lbs.	41.5	32.9	125.9
10	None	14.9[1]	14.9	None	26.0	13.6	69.4

[1]Estimated from 1903; no yield was taken in 1902 because of a misunderstanding.

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 26

GRUNDY COUNTY SOILS

By R. S. SMITH, E. E. DE TURK, F. C. BAUER, AND L. H. SMITH

URBANA, ILLINOIS, MARCH, 1924

The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

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INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or land owner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and land owner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due the late Professor J. G. Mosier, under whose direction the soil survey of Grundy county was conducted, and to Mr. S. V. Holt, who was in direct charge of the field party in the construction of the map.

CONTENTS OF SOIL REPORT No. 26

GRUNDY COUNTY SOILS

APPENDIX

SUPPLEMENT

GRUNDY COUNTY SOILS

BY R. S. SMITH, E. E. DE TURK, F. C. BAUER, AND L. H. SMITH[1]

LOCATION AND CLIMATE OF GRUNDY COUNTY

Grundy county is located in the northeastern part of Illinois about 70 miles from the northern boundary and covers an area of about 427 square miles. It lies principally in the early Wisconsin glaciation. The topography is, in general, gently undulating. About 65 percent of the area of the county is covered by prairie soils, 3 percent by timber soils, 23 percent by terrace soils, most of which are sandy, and 6 percent by swamp and bottom-land soils.

The climate of Grundy county is characterized by a wide range between the temperature extremes of winter and summer. Since there is no weather station of long standing in the county, the following data are taken from the Joliet station, which is located 12 miles from the northeast corner of Grundy county. The records for the years 1895 to 1920 show that the lowest temperature was 25° below zero in 1914, while the highest temperature for that year was 101°, thus making a range of 126 degrees. The highest temperature on record was 103° in 1897 and again in 1916. During the period from 1895 to 1920 the temperature reached zero or below every winter except one, that of 1906, in which the lowest temperature was 3° above; but in twenty-one winters in this period the temperature dropped to 10° or more below zero. The average date of the last killing frost in spring is May 1; the earliest in fall, October 9. The growing season, therefore, on the average, is about 161 days long.

The average annual precipitation at Joliet from 1894 to 1921 was 32.70 inches. The distribution of rainfall thruout the year is good, as shown by the following monthly averages: January, 1.89 inches; February, 1.58; March, 2.62; April, 2.69; May, 3.97; June, 3.30; July, 3.24; August, 3.27; September, 3.54; October, 2.59; November, 2.08; and December, 1.93. The proportion of total rainfall occurring during each season was: winter, 16.5 percent; spring, 28.4 percent; summer, 30.0 percent; autumn, 25.1 percent.

AGRICULTURAL PRODUCTION

Grundy county, like the other counties in this section, is primarily agricultural. It formerly contained a large acreage of what was classed as swamp land. However, in more recent years this land has been fairly well drained, so that but little actual swamp land now exists, altho much of the land might be more thoroly drained to its advantage.

In 1919 there were 1,506 farms in Grundy county, according to the Fourteenth Census of the United States. The average size of farm was 166.7 acres, 149.4 acres of which was improved land.

[1] R. S. Smith, in charge of soil survey mapping; E. E. DeTurk, in charge of soil analysis; F. C. Bauer, in charge of experiment fields; L. H. Smith, in charge of publications.

From this same census report we learn that about 72 percent of the area of the county is devoted to the production of field crops. The following figures show the acreage and production of the principal crops grown in the county. In considering these data, it must be remembered that the figures are for but a single year—that of 1919.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn	87,321	3,306,486 bu.	37.9 bu.
Oats	55,662	1,713,317 bu.	30.8 bu.
Wheat	33,097	590,511 bu.	17.8 bu.
Barley	392	8,745 bu.	22.3 bu.
Rye	4,310	51,449 bu.	11.9 bu.
Timothy	2,932	3,420 tons	1.17 tons
Timothy and clover mixed	3,091	3,694 tons	1.20 tons
Clover	3,570	4,515 tons	1.26 tons
Alfalfa	982	1,808 tons	1.84 tons
Silage crops	2,061	13,533 tons	6.57 tons
Corn for forage	566	1,243 tons	2.20 tons

The total value of all crops for 1919 was $8,205,682. According to data obtained from other sources, the area devoted to pasture is about 55,000 acres.

A crop not mentioned as such in the census report, but which is rapidly gaining prominence in Grundy county, is sweet clover. There is great interest in sweet clover, not only as a source of organic matter and nitrogen for soil improvement, but also as a valuable hay, seed, and pasture crop, and thousands of acres are now given over to its production.

The live-stock interests are of considerable importance, as shown by the following figures taken from this same census report.

Animals and animal products	*Number*	*Value*
Horses	11,851	$1,603,749
Mules	637	78,878
Beef cattle	8,421	563,097
Dairy cattle	8,676	523,779
Sheep	1,847	28,663
Swine	23,058	521,981
Chickens and other poultry	168,120	174,539
Eggs and chickens	——	502,153
Dairy products	——	247,798

The total value of the live-stock and their products was, according to these figures, a little over four million dollars.

Fruit growing has not been an important feature in the agricultural production of Grundy county. In 1919 there were about 9,000 quarts of berries produced and 3,240 bushels of apples, peaches, pears, and cherries. More attention might well be given to the production of fruit, especially for home use.

SOIL FORMATION

The most important period in the geological history of the county, from the standpoint of soil formation, was the Glacial period, during which the material that later formed the soils was being deposited. At that time, snow and ice accumulated in the region of Labrador, west of Hudson Bay, and in the Rocky Mountains in great masses. These masses pushed outward from their centers, especially southward, until a point was reached where the ice melted as rapidly as it advanced. As the ice advanced it buried everything, even the

LEGEND

900 Early Wisconsin Moraines

1000 Late Wisconsin Moraines

1100 Early Wisconsin Intermorainal Areas

(a) UPLAND PRAIRIE SOILS

- 26 Brown silt loam
- 20 Black clay loam
- 60 Brown sandy loam
- 281 / 1128 1 Brown silt loam on tight clay
- 28 / 1128 Brown-gray silt loam on tight clay
- 68 / 1168 Brown-gray sandy loam on tight clay
- 22 / 1122 Brown-gray clay loam on tight clay
- 1160.4 Brown sandy loam on gravel

(b) UPLAND TIMBER SOILS

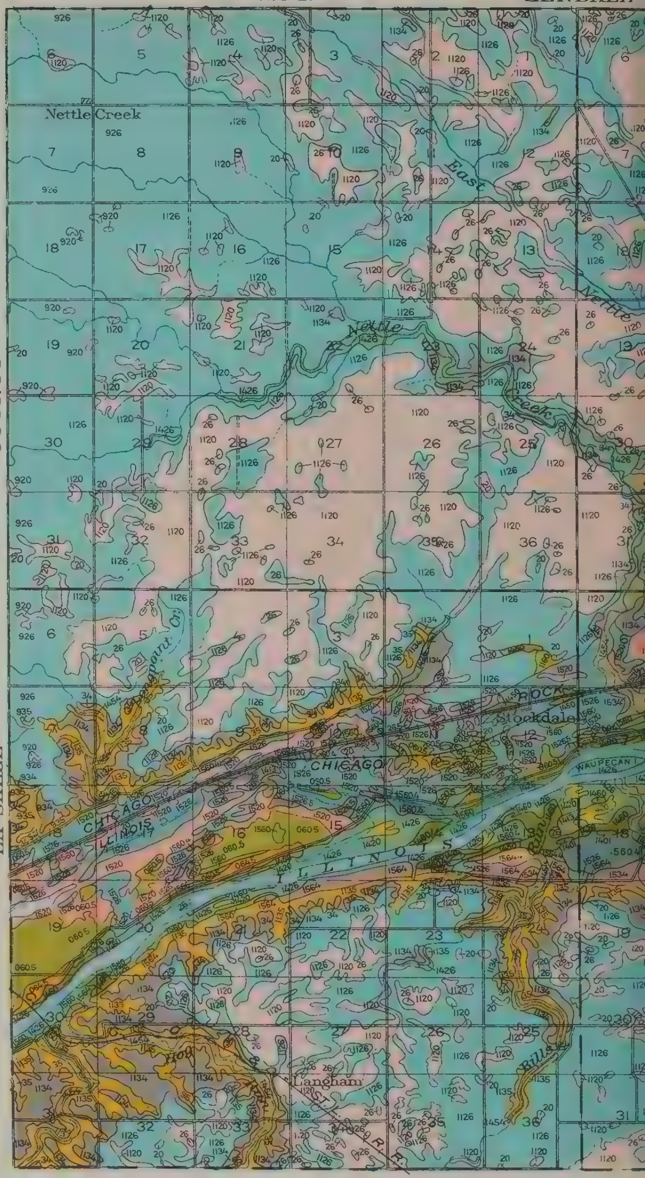
- 34 Yellow-gray silt loam
- 35 Yellow silt loam
- 64 Yellow-gray sandy loam
- 81 Dune sand

(c) 1500 TERRACE SOILS

- 26 / 1526 Brown silt loam
- 20 / 1520 Black clay loam
- 60 / 1560 Brown sandy loam
- 34 / 1534 Yellow-gray silt loam
- 64 / 1564 Yellow-gray sandy loam
- 28 / 1528 Brown-gray silt loam on tight clay
- 68 / 1568 Brown-gray sandy loam on tight clay
- 81 / 1581 Dune sand
- 61 / 1561 Black sandy loam
- 60.5 / 1560.5 Brown sandy loam on rock
- 26.5 / 1526.5 Brown silt loam on rock
- 66 / 1666 Brown sandy loam over gravel

R.6 E. KENDALL

LA SALLE COUNTY



- 64.4 / 1564.4 Yellow-gray sandy loam on gravel
- 60.4 / 1560.4 Brown sandy loam on gravel

(d) 1400 LATE SWAMP AND BOTTOM-LAND SOILS

- 26 / 1426 Deep brown silt loam
- 54 / 1454 Mixed loam
- 20 / 1420 Black clay loam
- 60 / 1460 Brown sandy loam
- 1450 Black mixed loam
- 1410 Peaty loam on clay

SOIL SURVEY

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Medium peat on clay

Deep peat

Muck on clay

Muck on marl

Swamp

Mine dumps

Scale

0 1/4 1/2 1 2 Miles

(e) 000 RESIDUAL SOILS

Brown sandy loam on rock

Yellow-gray sandy loam on rock

099 Rock outcrop

OF GRUNDY COUNTY

ULTURAL EXPERIMENT STATION

highest mountains, in its path. It would then recede slowly, and apparently normal conditions would be restored for a long period, after which another advance would occur. At least six of these great ice movements took place, each of which covered part of northern United States, altho the same parts were not covered during each ice advance.

In advancing from the distant northern centers of accumulation, the ice gathered up all sorts and sizes of material, including clay, silt, sand, gravel, boulders, and even large masses of rock. The character of this transported material varied with the character of the rocks over which the glacier passed. Some of these materials were carried several hundred miles, and the coarser masses rubbed against the surface rocks or against each other until largely ground into rock powder, which now constitutes much of the soil. When, thru the melting of the ice, the limit of advance was reached, the material carried by the glacier was left in a broad, undulating ridge or moraine, called a lateral moraine if formed at the side of the glacier, and a terminal moraine if formed at the end. When the ice melted more rapidly than the glacier advanced, the terminus of the glacier would recede, and the material would be deposited somewhat irregularly over the land back of the moraines. Such a formation is known as a ground moraine. A glacier often would advance again, but not so far as before; or it would remain stationary, and another moraine would be built up. These moraines or ridges have a steep outward slope and a very gradual inward slope.

A pressure of forty pounds per square inch is exerted by a mass of ice one hundred feet thick, and these ice sheets may have been hundreds or even thousands of feet in thickness. The materials carried along in the ice, especially the boulders and pebbles, became powerful agents for grinding and wearing away the surface over which the ice passed. Preglacial ridges and hills were rubbed down, valleys were filled with the debris, and the surface features were entirely changed. The mixture of materials deposited by the glacier is known as boulder clay, till, glacial drift, or simply drift.

Only four of the great glacial advances actually entered the area that now constitutes Grundy county. The first of these was the Illinoisan glacier, which covered the entire county. A later advance, the Iowan, probably invaded this county, but it is practically impossible to tell to what extent because the deposit which it left was buried by a subsequent glacier, the early Wisconsin. A later ice invasion, the late Wisconsin, occurred in this part of the state but touched only the northeastern part of Grundy county. It is very probable that the extensive sand and gravel deposits of the county were made during the melting of this last glacier.

The thickness of the glacial drift deposit in Grundy county varies from a few feet to as much as 140 feet, but the average thickness is probably not more than 75 or 80 feet. Sometimes in sinking wells, old soils are encountered which represent interglacial periods when normal conditions, so to speak, recurred.

The various agencies that have been at work in the transformation of soil material since the Glacial period necessarily have given the soils of the county a rather varied character.

It should be understood that the glacial drift itself makes up but a very small proportion of the actual soil material in this county, for after the Glacial period this region was covered by a stratum of wind-blown material called loess, which now varies from two to five feet in thickness. The loess constitutes a very large part of the present soil material. On the steeper slopes where considerable erosion has taken place, the drift may form part of the subsoil or even part of the subsurface and surface soil. As a rule, the loess provides better material for the formation of soils than does the glacial drift.

During the melting of the late Wisconsin glacier, the Illinois river swept over a large part of the extensive terrace region lying at the north of Mazonia and deposited there a considerable amount of sand and gravel, thus giving rise to a large area of sandy soils.

A glacial lake known as Glacial Lake Morris once covered a large portion of Grundy county and no doubt was an important factor in the formation of soil over the area which it covered. It was responsible for the heavy Black Clay Loam and also for those soils with heavy and tight subsoils, such as Brown-Gray Clay Loam On Tight Clay (1122.1) and Brown Silt Loam On Tight Clay (1128.1), as well as for the heavier subsoil of Brown Silt Loam (1126).

Besides these various agencies influencing the formation of the soils of this area, there has been another important factor. The topography, or natural lay of the land, has had much to do in bringing about the great variations now found in the accumulation of organic matter in these soils.

PHYSIOGRAPHY AND DRAINAGE

The surface of Grundy county forms an extensive rolling plain with a depression extending east and west thru which the Illinois river flows. The variation in topography is due to three agencies: first, and most important, to the more or less uniform deposition of material by glaciers, which resulted in the preservation of some of the pre-glacial irregularities; second, to postglacial erosion and deposition by streams, by which valleys were produced; third, to the transportation and deposition of sand by the wind. The greatest variation in topography is found in the northeast part of the county, where the range of altitude is 150 feet or more between the bottom land of the Illinois river and the crest of the Minooka ridge.

The Illinois river flows thru the county in a southwest direction, while nearly all the lesser streams both north and south of the Illinois flow southeast or northeast. This is due to the fact that the Marseilles moraine, which lies mainly over the line in LaSalle and Livingston counties, imparts an eastward slope to the land for some distance from the edge of the moraine. The principal streams draining the part of the county north of the Illinois river are Nettle and Aux Sable creeks. The principal streams south of the Illinois are Mazon river, with its several tributaries, Waupecan creek, Bills run, and Hog run.

The territory of Grundy county, at the close of the Glacial period, was largely covered by Glacial Lake Morris which left a large area of swamp land, as is indicated by the present extensive areas of Black Clay Loam. The terrace area in the county was also originally poorly drained. Artificial drainage, how-

LEGEND

900 Early Wisconsin Moraines

1000 Late Wisconsin Moraines

1100 Early Wisconsin Intermorainal Areas

(a) UPLAND PRAIRIE SOILS

- 26 Brown silt loam
- 20 Black clay loam
- 60 Brown sandy loam
- 28.1 / 1128.1 Brown silt loam on tight clay
- 28 / 1128 Brown-gray silt loam on tight clay
- 68 / 1168 Brown-gray sandy loam on tight clay
- 22.1 / 1122.1 Brown-gray clay loam on tight clay
- 1160.4 Brown sandy loam on gravel

(b) UPLAND TIMBER SOILS

- 34 Yellow-gray silt loam
- 35 Yellow silt loam
- 64 Yellow-gray sandy loam
- 81 Dune sand

(c) 1500 TERRACE SOILS

- 26 / 1526 Brown silt loam
- 20 / 1520 Black clay loam
- 60 / 1560 Brown sandy loam
- 34 / 1534 Yellow-gray silt loam
- 64 / 1564 Yellow-gray sandy loam
- 28 / 1528 Brown-gray silt loam on tight clay
- 68 / 1568 Brown-gray sandy loam on tight clay
- 81 / 1581 Dune sand
- 61 / 1561 Black sandy loam
- 60.5 / 1560.5 Brown sandy loam on rock
- 26.5 / 1526.5 Brown silt loam on rock
- 66 / 1566 Brown sandy loam over gravel

- 644 / 1564.4 Yellow-gray sandy loam on gravel
- 60.4 / 1560.4 Brown sandy loam on gravel

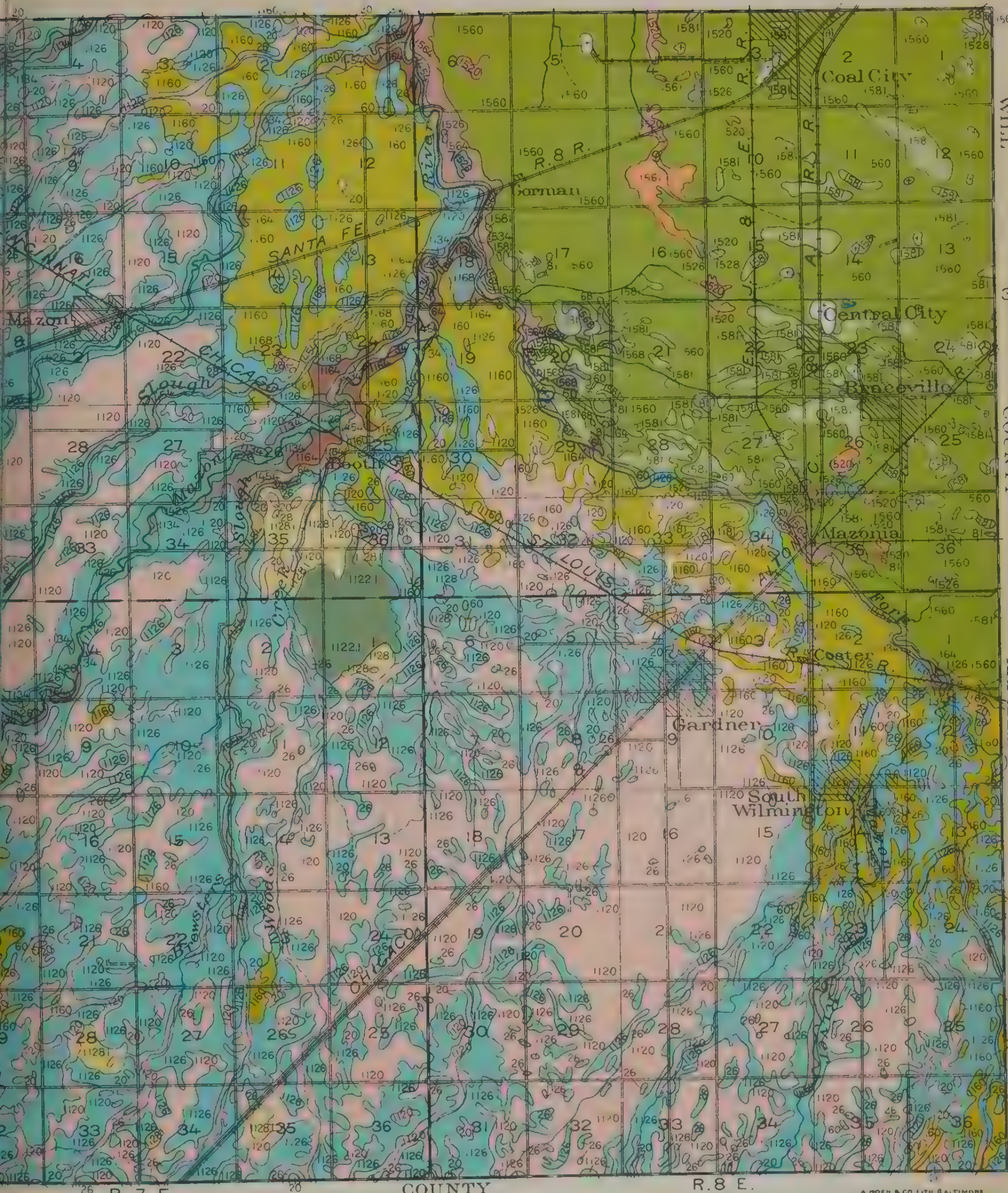
(d) 1400 LATE SWAMP AND BOTTOM-LAND SOILS

- 26 / 1426 Deep brown silt loam
- 54 / 1454 Mixed loam
- 20 / 1420 Black clay loam
- 60 / 1460 Brown sandy loam
- 1450 Black mixed loam
- 1410 Peaty loam on clay

SOIL SURVEY MA

UNIVERSITY OF ILLINOIS AG

SOUTH HALF



- Medium peat on clay
- Deep peat
- Muck on clay
- 136 Muck on marl
- Swamp
- Mine dumps

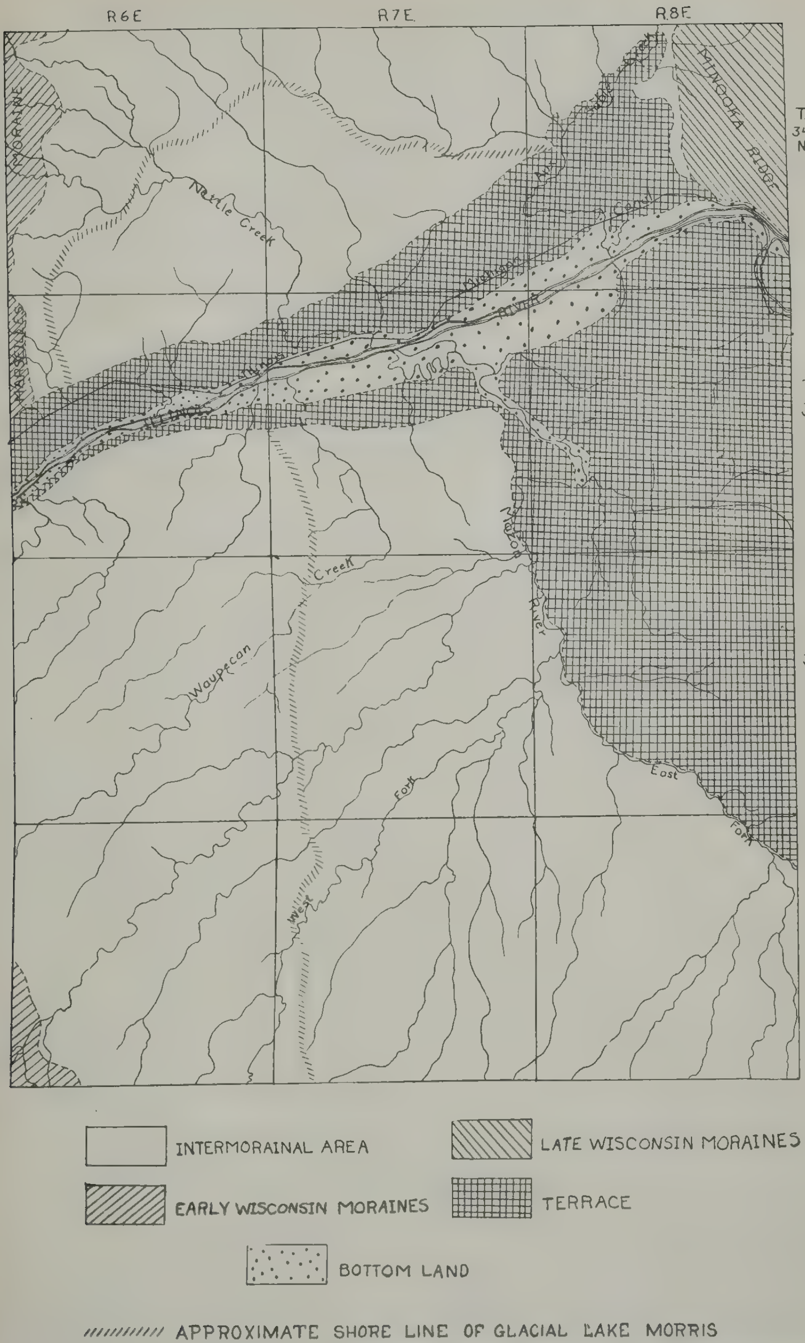
(e) 000 RESIDUAL SOILS

- 060.5 Brown sandy loam on rock
- 064.5 Yellow-gray sandy loam on rock
- 098 Rock outcrop

Scale

0 ¼ ½ 1 2 Miles

OF GRUNDY COUNTY
ULTURAL EXPERIMENT STATION



MAP SHOWING THE DRAINAGE BASINS OF GRUNDY COUNTY WITH MORAINAL, INTERMORAINAL, TERRACE, AND BOTTOM-LAND AREAS

ever, has been sufficiently provided so that the county as a whole is now fairly well drained, and practically all of the land is under cultivation.

The altitudes of some places in Grundy county are as follows: Braceville, 590 feet; Dell Abbey, 549; Divine, 525; Gardner, 590; Mazon, 592; Minooka, 632; Morris, 504; Nettle Creek, 648; Sand Ridge, 545; Stockdale, 522. Minooka Ridge reaches an altitude of about 635 feet. The drop to the Illinois river is very sudden, low water on the east county line being 490 feet. The highest point in the county is 710 feet in the northwest corner; the lowest, 465 feet, at low water in the Illinois river where it leaves the county. The southwest corner of the county has an altitude of 687 feet.

SOIL TYPES

The soils of Grundy county are classified under the following groups:

(a) *Upland Prairie Soils,* including the upland soils that have not been covered with forests—at least for any great length of time—and on which the luxuriant growth of prairie grasses has caused the accumulation of relatively large amounts of organic matter.

(b) *Upland Timber Soils,* including nearly all the upland areas that are now, or were formerly, covered with forests.

(c) *Terrace Soils,* including bench lands, or second bottom lands, formed by deposits from overloaded streams; and gravel outwash plains formed by broad sheets of water arising from the melting of the glaciers.

(d) *Swamp and Bottom-Land Soils,* including the overflow lands or flood plains along streams, the swamps, and the poorly drained lowlands.

(e) *Residual Soils,* including rock outcrop areas, and soils formed in place thru weathering of rocks.

Table 1 gives a list of the soil types found in Grundy county, classified according to the groups described above. It also shows the area of each type in square miles and in acres, and its percentage of the total area of the county.

TABLE 1.—SOIL TYPES OF GRUNDY COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (900, 1000, 1100)			
926, 1026, 1126	Brown Silt Loam	168.27	107,693	39.36
920, 1020, 1120	Black Clay Loam	95.07	60,845	22.24
1060, 1160	Brown Sandy Loam	17.49	11,193	4.09
1128.1	Brown Silt Loam On Tight Clay	1.32	845	.31
1128	Brown-Gray Silt Loam On Tight Clay	.73	467	.17
1168	Brown-Gray Sandy Loam On Tight Clay	.31	198	.07
1122.1	Brown-Gray Clay Loam On Tight Clay	1.02	653	.24
1160.4	Brown Sandy Loam On Gravel	.05	32	.01
		284.26	181,926	66.49

TABLE 1.—SOIL TYPES OF GRUNDY COUNTY, ILLINOIS, *Concluded*

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(b) Upland Timber Soils (900, 1000, 1100)			
934, 1034, 1134	Yellow-Gray Silt Loam	7.65	4,896	1.79
935, 1035, 1135	Yellow Silt Loam	4.28	2,739	1.00
1064, 1164	Yellow-Gray Sandy Loam	.80	512	.19
1181	Dune Sand	.08	51	.02
		12.81	8,198	3.00
	(c) Terrace Soils (1500)			
1526	Brown Silt Loam	17.82	11,405	4.17
1520	Black Clay Loam	10.55	6,752	2.47
1560	Brown Sandy Loam	49.45	31,648	11.57
1534	Yellow-Gray Silt Loam	2.56	1,638	.60
1564	Yellow-Gray Sandy Loam	2.09	1,338	.49
1528	Brown-Gray Silt Loam On Tight Clay	.32	205	.08
1568	Brown-Gray Sandy Loam On Tight Clay	.21	134	.05
1581	Dune Sand	6.62	4,237	1.55
1561	Black Sandy Loam	1.07	685	.25
1560.5	Brown Sandy Loam On Rock	1.47	941	.34
1526.5	Brown Silt Loam On Rock	1.78	1,139	.42
1566	Brown Sandy Loam Over Gravel	1.06	678	.24
1564.4	Yellow-Gray Sandy Loam On Gravel	.10	64	.02
1560.4	Brown Sandy Loam On Gravel	2.80	1,792	.65
		97.90	62,656	22.90
	(d) Swamp and Bottom-Land Soils (1400)			
1426	Deep Brown Silt Loam	13.40	8,576	3.14
1454	Mixed Loam	7.27	4,653	1.70
1420	Black Clay Loam	.45	288	.11
1460	Brown Sandy Loam	3.77	2,413	.85
1450	Black Mixed Loam	1.62	1,037	.39
1410	Peaty Loam On Clay	.15	96	.03
1402	Medium Peat On Clay	.14	90	.03
1401	Deep Peat	.38	243	.09
1413	Muck On Clay	.18	115	.05
1413.6	Muck On Marl	.01	6	.002
		27.37	17,517	6.40
	(e) Residual Soils			
060.5	Brown-Sandy Loam On Rock	1.34	857	.31
064.5	Yellow-Gray Sandy Loam On Rock	.20	128	.05
099	Rock Outcrop	.02	13	.004
		1.56	998	.36
	(f) Miscellaneous			
	Water	3.22	2,061	.76
	Mine Dumps	.30	192	.07
	Swamp	.12	77	.02
		3.64	2,330	.85
	Total	427.54	273,625	100.00

For explanations concerning the classification of soils and the interpretation of the map and tables, the reader is referred to the Appendix to this report.

INVOICE OF THE ELEMENTS OF PLANT FOOD IN GRUNDY COUNTY SOILS

In order to obtain a knowledge of its chemical composition, each soil type is sampled in the manner described below and subjected to chemical analysis for its important plant-food elements. For this purpose samples are taken usually in sets of three to represent different strata in the top 40 inches of soil; namely, an upper stratum (0 to 6⅔ inches), a middle stratum (6⅔ to 20 inches), and a lower stratum (20 to 40 inches). These sampling strata correspond approximately in the common kinds of soil to 2,000,000 pounds per acre of dry soil in the upper stratum, and to two times and three times this quantity in the middle and lower strata respectively. This, of course, is a purely arbitrary division of the soil section, very useful in arriving at a knowledge of the quantity and distribution of the elements of plant food in the soil, but it should be borne in mind that these strata seldom coincide with the natural strata as they actually exist in the soil and which are referred to in describing the soil types as surface, subsurface, and subsoil. By this system of sampling we have represented separately three zones for plant feeding. The upper, or surface layer, includes at least as much soil as is ordinarily turned with the plow, and this is the part with which the farm manure, limestone, phosphate, or other fertilizing material is incorporated.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed, but it should be understood that the rate of liberation from their insoluble forms is governed by many factors.

For convenience in making application of the chemical analyses, the results as presented here have been translated from the percentage basis and are given in the accompanying tables in terms of pounds per acre. In this, the assumption is made that for ordinary types a stratum of dry soil of the area of an acre and 6⅔ inches thick weighs 2,000,000 pounds, exceptions being made of certain soils very high in organic matter, such as the peats and the mucks. It is understood, of course, that this value is only an approximation but it is believed that, with this understanding, it will suffice for the purposes intended. It is, of course, a simple matter to convert these figures back to the percentage basis in case one desires for any purpose to consider the information in that form.

THE UPPER SAMPLING STRATUM

In Table 2 are reported the amount of organic carbon (which serves as a measure of the total organic matter), and the total quantities of nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium in 2 million pounds of the surface soil of each type in Grundy county.

Because of the extreme variations frequently found within a given soil type with respect to the presence of limestone and acidity in the different strata, no attempt is made to include in the tabulated results figures purporting to represent their averages in the respective types. In examining each soil type, however, qualitative tests are made which furnish general information regarding the soil reaction, and in the discussions of the individual soil types which follow,

recommendations based upon these tests are given concerning the lime requirement of the respective types. Such recommendations cannot be made specific in all cases because local variations exist, and because the lime requirement may change from time to time, especially under cropping. Therefore it is often desirable to determine the lime requirement for a given field and in this connection the reader is referred to the section in the Appendix dealing with the application of limestone (page 43).

In looking over Table 2 it is of interest to note the marked variation among the different soil types with respect to the content of the various plant-food elements. For example, observing the variation in nitrogen it may be noted that the type, Medium Peat On Clay, contains in the plowed soil of an acre about 28 times as much nitrogen as Dune Sand, Terrace. Comparing this same type, Medium Peat On Clay, with the commonest type in the county, Brown Silt Loam, we find that the former contains nearly four times as much nitrogen as the latter while with respect to potassium the position is exactly reversed, the latter containing nearly four times as much potassium as the former. The supply of phosphorus in the surface layer varies from 540 pounds per acre in Dune Sand, Terrace, to 2240 pounds per acre in Brown Silt Loam On Rock, Terrace. A sulfur content of only 160 pounds per acre is found in the Dune Sand, while in an equal volume of Medium Peat On Clay the analysis shows more than 5000 pounds of this element. In like manner the magnesium varies in the different types from 2,100 to more than 17,000 pounds, and the calcium content ranges from less than 3,000 pounds, to nearly 30,000 pounds per acre.

THE MIDDLE AND LOWER SAMPLING STRATA

In Tables 3 and 4 are recorded in a similar manner the amounts of the plant-food elements in the middle and lower sampling strata. It is frequently of interest to know the total supply of a plant-food element accessible to the growing crops. While it is impracticable to obtain this information exactly, because of the variation in root growth, it may be assumed that the bulk of the feeding range of the roots of most of our common field crops is included in the upper 40 inches of soil. By adding together for a given soil type the corresponding figures in Tables 2, 3, and 4, the total amounts of the respective plant-food elements to a depth of 40 inches may be ascertained.

A wide range of variation with respect to composition is found to occur in the sub-layers as well as in the top layer of the various soil types. The tables reveal further that there is not only this wide diversity among the different soils with respect to a given plant-food element, but that there is also a great variation with respect to the relative abundance of various elements within a given soil type as measured by crop requirements. For example, in the commonest type in the county, Brown Silt Loam, we find that the total quantity of nitrogen in an acre to a depth of 40 inches amounts to 16,180 pounds. This is about the amount of nitrogen contained in 16,000 bushels of corn. On the other hand there is present in the same quantity of this soil 251,970 pounds of potassium, or the equivalent of that contained in nearly 1⅓ million bushels of corn.

TABLE 2.—PLANT-FOOD ELEMENTS IN THE SOILS OF GRUNDY COUNTY, ILLINOIS
UPPER SAMPLING STRATUM: ABOUT 0 TO 6⅔ INCHES

Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (1000, 1100)							
1026, 1126	Brown Silt Loam	72 080	5 670	1 070	1 230	37 000	8 370	11 200
1120	Black Clay Loam	78 960	6 840	1 580	1 340	36 420	11 860	29 890
1160	Brown Sandy Loam	63 990	5 020	1 130	1 200	27 080	6 560	18 690
1128.1	Brown Silt Loam On Tight Clay	50 800	4 380	940	760	39 940	7 480	8 360
1128	Brown-Gray Silt Loam On Tight Clay	44 740	3 860	1 020	920	36 600	5 880	8 740
1168	Brown-Gray Sandy Loam On Tight Clay	35 860	3 000	740	500	19 400	2 940	5 260
1122.1	Brown Gray Clay Loam On Tight Clay	59 900	4 960	940	1 040	43 360	11 160	11 920
1160.4	Brown Sandy Loam On Gravel	53 820	4 620	1 500	1 480	25 620	6 260	10 680
	(b) Upland Timber Soils (1000, 1100)							
1034, 1134	Yellow-Gray Silt Loam	31 960	2 630	780	730	36 860	5 690	10 940
1135	Yellow Silt Loam	26 500	2 360	580	720	41 560	8 120	7 040
1164	Yellow-Gray Sandy Loam	22 980	1 800	720	480	29 200	4 880	5 830
1181	Dune Sand	15 680	1 080	520	420	21 080	2 100	6 700
	(c) Terrace Soils (1500)							
1526	Brown Silt Loam	77 150	6 540	1 500	1 380	38 310	11 900	19 950
1520	Black Clay Loam	76 950	6 300	1 480	1 550	51 250	17 120	18 180
1560	Brown Sandy Loam	59 870	5 700	930	980	21 750	4 910	15 930
1534	Yellow-Gray Silt Loam	31 620	2 460	880	700	37 620	5 660	8 200
1564	Yellow-Gray Sandy Loam	21 740	1 760	560	340	27 860	3 920	7 000
1528	Brown-Gray Silt Loam On Tight Clay	49 860	4 640	920	680	44 200	11 360	8 680
1568	Brown-Gray Sandy Loam On Tight Clay	29 360	4 440	920	780	17 860	2 700	6 400
1581	Dune Sand	12 520	770	540	160	21 470	2 740	5 460
1561	Black Sandy Loam	64 600	5 520	1 140	1 140	28 280	7 320	14 020
1560.5	Brown Sandy Loam On Rock	80 000	6 300	1 280	1 400	25 600	3 540	3 600
1526.5	Brown Silt Loam On Rock	111 180	9 180	2 240	1 780	40 920	11 900	17 260
1566	Brown Sandy Loam Over Gravel	22 260	2 240	900	400	26 400	4 500	5 920
1564.4	Yellow-Gray Sandy Loam On Gravel	19 420	1 540	920	400	23 900	4 460	9 380
1560.4	Brown Sandy Loam On Gravel	33 220	2 660	1 500	580	27 340	6 580	9 960

TABLE 2.—PLANT-FOOD ELEMENTS IN THE SOILS OF GRUNDY COUNTY, ILLINOIS, *Concluded*

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(d) Late Swamp and Bottom-Land Soils (1400)							
1426	Deep Brown Silt Loam	72 350	6 380	1 060	1 090	48 940	16 950	22 070
1454	Mixed Loam[1]							
1420	Black Clay Loam	87 560	7 860	1 780	1 420	43 920	14 380	18 760
1460	Brown Sandy Loam	49 780	4 280	980	700	30 260	5 260	8 700
1450	Black Mixed Loam[1]							
1410	Peaty Loam On Clay[3]	197 930	15 680	1 290	2 610	18 230	5 720	18 000
1402	Medium Peat On Clay[2]	264 800	21 380	970	5 280	9 820	7 160	21 460
1401	Deep Peat[2]	175 810	13 040	1 120	2 380	9 410	3 720	12 740
1413	Muck On Clay[3]	117 680	9 350	1 590	1 280	33 410	10 040	14 570
1413.6	Muck On Marl[3]	72 150	9 530	1 020	1 140	22 400	8 360	21 330
	(e) Residual Soils (000)							
060.5	Brown Sandy Loam On Rock	74 680	6 240	1 140	1 040	21 040	3 180	2 320
064.5	Yellow-Gray Sandy Loam On Rock	26 720	3 120	980	940	26 500	5 140	3 140
099	Rock Outcrop							

LIMESTONE AND SOIL ACIDITY.—In connection with these tabulated data it should be explained that the figures for limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in the form of general numerical averages reliable information concerning the limestone requirement for a given soil type. A general statement, however, will be found concerning the lime requirement of the respective soil types in connection with the discussions which follow.

[1]On account of the heterogeneous character of Mixed Loam and Black Mixed Loam chemical analyses are not included for these types.
[2]Amounts reported are for 1 million pounds.
[3]Amounts reported are for 1½ million pounds.

TABLE 3.—PLANT-FOOD ELEMENTS IN THE SOILS OF GRUNDY COUNTY, ILLINOIS
MIDDLE SAMPLING STRATUM: ABOUT 6⅔ TO 20 INCHES
Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (1000, 1100)							
1026, 1126	Brown Silt Loam	80 200	7 190	1 670	1 600	76 140	21 470	21 460
1120	Black Clay Loam	65 110	5 960	2 430	1 610	76 460	21 730	34 120
1160	Brown Sandy Loam	62 180	5 640	1 800	1 620	56 320	14 620	20 520
1128.1	Brown Silt Loam On Tight Clay	48 400	4 480	1 200	1 040	83 160	23 800	13 920
1128	Brown-Gray Silt Loam On Tight Clay	48 640	4 200	1 760	1 400	74 720	16 360	16 560
1168	Brown-Gray Sandy Loam On Tight Clay	24 080	1 720	920	520	39 520	6 080	9 160
1122.1	Brown-Gray Clay Loam On Tight Clay	58 360	5 320	1 280	1 600	94 680	29 800	20 680
1160.4	Brown Sandy Loam On Gravel	77 800	4 760	2 240	1 920	50 560	40 440	71 200
	(b) Upland Timber Soils (1000, 1100)							
1034, 1134	Yellow-Gray Silt Loam	24 460	2 300	1 560	980	75 500	16 480	20 160
1135	Yellow Silt Loam	27 200	3 080	1 320	1 360	134 000	49 520	30 760
1164	Yellow-Gray Sandy Loam	19 440	1 560	1 240	680	61 480	11 760	7 280
1181	Dune Sand	28 680	1 720	840	720	42 240	5 120	1 480
	(c) Terrace Soils (1500)							
1526	Brown Silt Loam	67 380	6 040	1 940	1 720	79 280	53 240	81 500
1520	Black Clay Loam	74 440	6 920	2 320	1 520	100 900	39 500	41 760
1560	Brown Sandy Loam	28 360	2 720	1 150	560	45 930	8 840	19 710
1534	Yellow-Gray Silt Loam	32 760	2 560	1 480	1 120	78 400	15 480	15 920
1564	Yellow-Gray Sandy Loam	15 600	1 400	1 080	920	67 040	22 000	21 520
1528	Brown-Gray Silt Loam On Tight Clay	39 640	4 480	1 040	840	105 680	35 160	14 920
1568	Brown-Gray Sandy Loam On Tight Clay	41 080	2 920	1 080	640	40 680	6 240	12 000
1581	Dune Sand	10 640	720	960	120	44 220	6 000	11 020
1561	Black Sandy Loam	46 880	3 880	1 360	880	58 640	13 680	23 040
1560.5	Brown Sandy Loam On Rock	38 600	3 120	1 120	1 520	60 240	3 560	28 080
1526.5	Brown Silt Loam On Rock	127 400	11 040	3 600	2 560	87 920	27 520	57 440
1566	Brown Sandy Loam Over Gravel	43 680	3 400	1 640	560	57 680	10 760	13 320
1564.4	Yellow-Gray Sandy Loam On Gravel	22 880	1 560	1 320	440	44 480	11 400	21 680
1560.4	Brown Sandy Loam On Gravel	53 800	4 440	2 800	1 240	54 920	15 000	22 400

TABLE 3.—PLANT-FOOD ELEMENTS IN THE SOILS OF GRUNDY COUNTY, ILLINOIS, *Concluded*

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(d) Late Swamp and Bottom-Land Soils (1400)							
1426	Deep Brown Silt Loam	102 360	9 980	3 080	1 720	95 180	28 640	37 320
1454	Mixed Loam[1]							
1420	Black Clay Loam	91 960	8 560	2 240	1 480	81 920	22 120	29 680
1460	Brown Sandy Loam	52 840	4 080	1 480	640	59 800	8 560	14 440
1450	Black Mixed Loam[1]							
1410	Peaty Loam On Clay[3]	332 670	26 760	1 740	4 560	42 390	11 490	31 380
1402	Medium Peat On Clay[2]	343 540	28 900	880	8 600	30 040	11 980	41 180
1401	Deep Peat[2]	378 420	30 000	1 860	5 420	17 160	10 840	37 720
1413	Muck On Clay	222 120	18 240	3 240	2 000	84 560	27 480	34 320
1413.6	Muck On Marl	78 080	7 520	1 960	2 320	51 800	23 320	183 200
	(e) Residual Soils (000)							
060.5	Brown Sandy Loam On Rock	31 680	2 680	1 080	1 040	53 520	8 440	6 120
064.5	Yellow-Gray Sandy Loam On Rock	20 480	1 840	1 400	600	56 480	6 960	4 600
099	Rock Outcrop							

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1]On account of the heterogeneous character of Mixed Loam and Black Mixed Loam chemical analyses are not included for these types.
[2]Amounts reported are for 2 million pounds.
[3]Amounts reported are for 3 million pounds.

TABLE 4.—PLANT-FOOD ELEMENTS IN THE SOILS OF GRUNDY COUNTY, ILLINOIS
LOWER SAMPLING STRATUM: ABOUT 20 TO 40 INCHES

Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phos-phorus	Total sulfur	Total potas-sium	Total magne-sium	Total calcium
	(a) Upland Prairie Soils (1000, 1100)							
1026 1126	Brown Silt Loam	35 730	3 320	1 890	1 440	138 830	67 490	105 720
1120	Black Clay Loam	34 270	3 170	3 060	1 320	124 620	59 900	76 500
1160	Brown Sandy Loam	27 900	2 250	2 010	1 320	95 430	38 550	48 450
1128.1	Brown Silt Loam On Tight Clay	29 940	3 540	1 920	1 320	153 060	58 800	30 900
1128	Brown-Gray Silt Loam On Tight Clay	37 620	3 480	2 220	1 560	145 980	69 000	76 440
1168	Brown-Gray Sandy Loam On Tight Clay	26 700	1 920	1 260	480	66 300	16 560	17 220
1122.1	Brown-Gray Clay Loam On Tight Clay	31 380	3 180	2 160	16 680	149 520	57 300	53 940
	(b) Upland Timber Soils (1000, 1100)							
1034 1134	Yellow-Gray Silt Loam	29 700	2 640	2 730	1 500	116 250	88 290	159 510
1135	Yellow Silt Loam	35 160	3 660	2 040	2 100	200 220	176 520	222 660
1164	Yellow-Gray Sandy Loam	26 220	2 340	2 280	960	95 220	32 100	39 240
1181	Dune Sand	26 460	1 380	900	600	63 960	7 680	6 180
	(c) Terrace Soils (1500)							
1526	Brown Silt Loam	34 170	3 030	2 500	1 680	126 870	149 970	180 960
1520	Black Clay Loam	56 790	4 710	2 700	1 800	142 470	128 580	184 470
1560	Brown Sandy Loam	16 220	1 180	1 100	520	64 740	16 700	49 220
1534	Yellow-Gray Silt Loam	46 080	3 120	2 580	1 440	105 840	155 520	243 540
1564	Yellow-Gray Sandy Loam	14 940	1 200	960	1 080	89 340	21 000	18 300
1528	Brown-Gray Silt Loam On Tight Clay	20 580	3 540	1 620	1 740	170 340	65 880	25 320
1568	Brown-Gray Sandy Loam On Tight Clay	20 520	1 740	720	840	63 900	12 660	19 140
1581	Dune Sand	10 830	540	1 530	390	64 350	7 650	17 220
1561	Black Sandy Loam	16 680	1 560	1 080	1 020	86 280	11 640	25 560
1566	Brown Sandy Loam Over Gravel	34 380	2 760	2 400	720	91 500	22 620	20 880

TABLE 4.—PLANT-FOOD ELEMENTS IN THE SOILS OF GRUNDY COUNTY, ILLINOIS, *Concluded*

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(d) Late Swamp and Bottom-Land Soils (1400)							
1426	Deep Brown Silt Loam	90 180	8 280	3 390	1 980	141 750	48 390	52 830
1454	Mixed Loam[1]							
1420	Black Clay Loam	72 300	6 540	4 560	1 620	125 040	30 720	46 920
1460	Brown Sandy Loam	42 420	1 980	1 260	420	77 760	10 020	20 460
1450	Black Mixed Loam[1]							
1410	Peaty Loam On Clay[3]	252 770	17 100	1 800	10 530	81 000	23 400	43 160
1402	Medium Peat On Clay[2]	256 500	18 180	1 080	30 180	58 800	32 580	124 500
1401	Deep Peat[2]	280 650	23 340	1 950	5 730	28 080	10 470	30 930
1413	Muck On Clay	234 900	16 500	3 420	2 280	141 420	45 420	44 640
1413.6	Muck On Marl	35 160	3 120	1 980	1 860	52 620	67 080	1 051 560

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1]On account of the heterogeneous character of Mixed Loam and Black Mixed Loam chemical analyses are not included for these types.
[2]Amounts reported are for 3 million pounds.
[3]Amounts reported are for 4½ million pounds.

These statements are not intended to imply that it is possible to predict how long it might be before a certain soil would become exhausted under a given system of cropping. Neither do the figures necessarily indicate the immediate procedure to be followed in the improvement of a soil, for other factors enter into consideration aside from the mere amount of plant-food elements present in the soil. Much depends upon the nature of the crops to be grown as to their utilization of plant food, and much depends upon the condition of the plant-food substances themselves as to their availability. Finally in planning the detailed procedure for the improvement of a soil, there enter for consideration all the economic factors involved in any fertilizer treatment. Such figures do, however, furnish an inventory of the total stocks of plant-food elements that can possibly be drawn upon and in this way these chemical data contribute fundamental information for the intelligent planning in a broad way of systems of soil management for conserving and improving the fertility of the land.

DESCRIPTION OF INDIVIDUAL SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of Grundy county cover 284.26 square miles, or two-thirds of the area of the county. Owing to the accumulation of organic matter, derived very largely from the roots of the prairie grasses that once covered the land, the soils of this group are dark in color, varying from dark brown to black. The network of comparatively thick roots of these grasses was protected from complete decomposition by imperfect aeration resulting from the covering of fine, moist soil material. The flat prairie contains a higher amount of organic matter than the more rolling land because the grasses grew more luxuriantly there and the higher moisture content retarded the decay of their roots. The material resulting from this partial decomposition is a black substance of varying chemical composition. Some of it has probably been in the soil for many thousands of years and has reached a stage similar to coal. It is almost wholly resistant to decay. This old organic matter, as well as that more recently formed, gives a dark color to the soil.

The upland prairie soils in this county include some areas of recent timber growth, where certain kinds of trees have invaded the prairie but have not grown for a long enough time to produce the characteristic timber soil. These areas are usually narrow and are found along the border of most timber tracts. In consulting the map, therefore, one should have in mind the fact that the timber may actually extend a little farther than the soil type would appear to indicate.

Brown Silt Loam (926, 1026, 1126)

Brown Silt Loam is the most extensive soil type in Grundy county. It varies considerably in different portions of the county in depth, color, texture, topography and composition. Rolling morainal areas occur in the northeast, northwest, and southwest corners of the county. In these areas the tops and slopes of the ridges are of a shallower and lighter colored soil than is found in

the low, more nearly flat areas, and the glacial till is frequently found 30 inches or less from the surface. The Brown Silt Loam bordering the sandy terrace is generally a sandy phase of silt loam and contains areas of sandy loam which are too small to be shown on the map. The remainder of the Brown Silt Loam area in the county is flat to gently undulating in topography, and generally heavier and deeper than is normal for the type. Tile drainage is common thruout the more level portions.

The following description applies to this type as it has been found to occur in Grundy county. The surface soil varies in depth from 9 to 12 inches, in color from a brownish black to a light brown, and in texture from a sandy silt loam to a heavy or clayey silt loam. This stratum is fairly well supplied with organic matter; however, it is not at all uncommon for the amount of fresh, active organic matter to be reduced to a point where the tilth of the soil is unfavorably affected. The subsurface, which extends to a depth of 17 to 28 inches, varies from a grayish brown to a mottled, light yellowish silt loam to silty clay loam. The subsoil is a fairly compact, but pervious, mottled, yellow clay to a depth of 34 to 40 inches, where it passes into a more friable and usually a grayer and more strongly mottled clay loam. Strong effervescence with acid shows the presence of limestone at a depth of 30 to 40 inches.

Management.—The first essential in the management of the type is to install drainage where needed. The next step is to apply ground limestone when tests show the soil to be acid. A large portion of the area covered by this type is not yet in need of limestone in the surface, and carbonate of lime is uniformly found in the subsoil at a depth of 30 to 45 inches. The higher, more rolling areas are acid in the surface, tho not strongly so, and it is recommended that about two tons of ground limestone per acre be applied to these areas. With the drainage and the need for lime provided for, the way is open for taking care of the organic-matter and nitrogen needs of the soil.

Brown Silt Loam, when it is first brought under cultivation, is rich in fresh organic matter and good tilth is easily maintained. Continuous cropping, with its inevitable destruction of organic matter, has in many cases resulted in such a depletion of this important soil material that a condition of poor tilth has followed. It is probably unnecessary to keep the organic-matter content of this type at its original high level, but provision should be made for returning sufficient fresh organic matter so that a reasonable amount of tillage will produce a condition of good tilth. Such a condition cannot be maintained without the frequent plowing down of fresh organic matter such as crop residues, barnyard manure, catch crops, and, if necessary, entire legume crops. The fact that this soil is dark brown or black in color does not mean that it is sufficiently supplied with organic matter. The dark color is largely imparted by the well-decayed, resistant, black colored portions of the organic matter, and these portions have comparatively little value, either chemical or physical. Another reason of prime importance for making full use of all the sources of organic matter, particularly of leguminous plants, is to secure and conserve the nitrogen supply. Red and alsike clover will grow fairly satisfactorily on this type without the use of lime, excepting on the more rolling portions. Alfalfa and sweet clover, however, will

usually not do well until the land has been limed, particularly on the higher areas.

The evidence regarding the use of phosphate fertilizers on this type is not entirely satisfactory. The experiment field results indicate that either steamed bone meal or rock phosphate can be used at a profit on the higher, lighter colored areas. They also indicate that it is doubtful whether rock phosphate can be used profitably on the heavier areas. No information is available as to whether steamed bone meal can be profitably used on the heavier areas. If rock phosphate is used, it should be applied with organic matter at the rate of about half a ton per acre every four or five years. If one of the soluble forms of phosphate is used, it should be applied in amounts sufficient to compensate for that removed by crops, and preferably on the wheat. See discussion of the phosphorus problem in the Appendix, page 45.

If grain farming is practiced, the rotation may be wheat, corn, oats, and clover, with an extra seeding of clover (preferably sweet clover) as a catch crop in the wheat, to be plowed under for corn the following year. The crop residues, with the possible exception of wheat and oat straw, including the clover chaff from the seed crops, should be plowed under. In live-stock farming, the regular rotation may be extended to five or six years by seeding both timothy and clover with the oats, and pasturing one or two years. Alsike may well replace red clover at times, and the value of sweet clover is well recognized in this county. In either system, grain or live-stock, alfalfa may be grown on a fifth field, moving to another field at the end of a rotation, or it may be used in the regular rotation in place of all or a part of the clover. For other suggestions concerning crop rotations, the reader is referred to the Appendix, page 50. The results of field experiments on Brown Silt Loam are given in the Supplement, page 54.

Black Clay Loam (920, 1020, 1120)

Black Clay Loam is one of the flat, heavy, prairie-land types. It is sometimes called "gumbo," because of its sticky character. Its formation in the flat, poorly drained areas is due to the accumulation of organic matter and to the washing in of clay and fine silt from the slightly higher adjoining lands, or to deposition from the slowly moving water of a lake or a swamp. This type in Grundy county occurs to a very large extent within the limits of Glacial Lake Morris, both north and south of the Illinois river (see drainage map). Numerous streams were responsible for carrying and depositing the fine sediment entering into the formation of the soils on the lake bed. This type occupies 95.07 square miles, or more than one-fifth of the area of the county.

The surface soil is a black, granular, clay loam of medium plasticity to a depth of about 9 inches. It is well supplied with total organic matter, but is generally becoming deficient in active or easily decomposable organic materials. The subsurface extends to a depth of 19 to 27 inches, and is a yellowish or brownish drab clay loam. Considerable variation in color is found in the subsurface indicating differences in drainage. The subsoil to a depth of 36 to 40 inches is a mottled yellow, or mottled drab clay, usually not readily permeated by water, owing to compaction. As a rule, strong effervescence with an acid

is found at about 36 inches, showing the presence of large amounts of carbonate of lime.

Management.—The most important consideration in the management of this type is to maintain good tilth. This condition is promoted by providing good underdrainage and maintaining the supply of fresh organic matter by the use of crop residues, legume catch crops, and green manures. Numerous tests show that it is not necessary to apply limestone, as the surface soil is neutral or alkaline and carbonates always occur in the subsoil.

While Black Clay Loam is one of the best soils in the state, yet its fine texture gives it the property of shrinkage and expansion to such a degree as to be somewhat objectionable at times, especially during drouth. When the soil is wet, it expands, and when the moisture evaporates or is used by the crops, it shrinks. This results in the formation of cracks which extend two or three feet in depth and which are sometimes two or more inches wide at the surface. These cracks allow the soil to dry out rapidly, and as a result the crop is injured thru lack of moisture. They may do considerable damage by ''blocking out'' hills of corn and severing the roots. While cracking may not be prevented entirely, good tilth and a soil mulch will do much toward that end. Cultivation is more essential on this heavy type than on the lighter types of soil. It must be remembered, however, that cultivation should be as shallow as possible in order to avoid injuring the roots of the cultivated crop.

Brown Sandy Loam (1060, 1160)

The mixed wind and water origin of Brown Sandy Loam has resulted in a great variation in the type. The area found in the southwest corner of Good Farm township (Township 31 North, Range 7 East) is heavier and naturally more poorly drained than that which occurs as a belt bordering the sandy terrace. The color varies from a light brown on the sandier dune-like portions to dark brown or black on the lower, heavier areas. Wide variations in the chemical composition of the type, as well as in its physical properties, are shown by the analyses of samples collected to represent the type.

The surface soil, which is 8 to 10 inches deep, is predominantly a brown sandy loam. The low ridges or dune-like formations are lighter in color and coarser in texture and the flat areas, particularly in Good Farm township, are dark brown to black and contain enough silt and clay to make the soil a heavy phase of sandy loam. The subsurface, which extends to a depth of 20 to 22 inches, is a fairly distinct stratum of grayish brown to gray sandy loam or clayey sand in the more poorly drained areas, becoming mottled yellow where the drainage is better. The subsoil begins at a depth of 20 to 22 inches. It is a gray to mottled yellow sandy clay, rather compact, and passes into gray sand or mottled yellow till at 30 to 45 inches in depth.

Management.—No specific recommendations can be given for the management of this type as a whole, because of the wide variations found to exist. In general, the lighter colored areas require the application of about 2 tons of limestone per acre in order to grow alfalfa or sweet clover, while the low flat areas need no lime.

The coarse texture of the sandier phases of the type makes it difficult to maintain organic matter because of rapid decay resulting from too much aeration. Cowpeas and soybeans can be grown successfully on these sandier areas without limestone, while sweet clover, which is an important crop in Grundy county, does well if limestone is used. Alfalfa is also a good crop for this kind of land, altho it is more difficult to start on this sandy soil than on heavier soil.

The phosphorus content of the sandier phase of the type is low. No definite information is available as to what form of phosphate can be used at a profit, or whether phosphate in any form can be so used. The best information available indicates that it is very doubtful whether rock phosphate will return a profit on the sandier phases of the type. It is reasonable to suppose that the more soluble forms, either steamed bone meal or acid phosphate, if properly used, will prove profitable and at the same time will maintain or increase the total phosphorus supply in the soil.

As a rule, Brown Sandy Loam is naturally well drained, altho there are areas thruout the type which have poor natural drainage, particularly in Good Farm township.

Brown Silt Loam On Tight Clay (1128.1)

Brown Silt Loam On Tight Clay occurs in small areas in the south central part of the county and in the northeast corner. It resembles Brown Silt Loam in the surface, but the subsoil is very different, in that it is impervious.

The surface soil is a brown silt loam with a grayish tint. It passes into the subsurface, which is a yellowish brown silt loam, at a depth of 9 to 10 inches. The subsoil begins at a depth of 16 to 20 inches. It is a drab clay, strongly mottled with yellow. The subsoil is very plastic and is impervious to air and water.

Management.—Drainage of this type is difficult because of the presence of the impervious subsoil. The type is not strongly acid but for the growth of sweet clover about 2 tons of limestone per acre is recommended.

Brown-Gray Silt Loam On Tight Clay (1128)

Only a few small areas of Brown-Gray Silt Loam On Tight Clay are found in Grundy county. The surface soil is a grayish brown silt loam about 8 inches in depth. The subsurface is a dark grayish or brownish gray silt loam which extends to a depth of about 20 inches. The subsoil is a compact, impervious, mottled, drab clay.

Management.—The management of this type is the same as that suggested for Brown Silt Loam On Tight Clay.

Brown-Gray Sandy Loam On Tight Clay (1168)

Brown-Gray Sandy Loam On Tight Clay is found in the vicinity of the other tight clay types. This type is of minor importance, as there is but little of it in Grundy county.

The surface is a brownish gray sandy loam about 8 inches in depth. The subsurface, which extends to a depth of about 18 inches, is a gray to brownish

gray sandy loam. The subsoil is a mottled brownish gray or drab colored, compact, impervious clay.

Management.—An application of limestone at the rate of 2 tons per acre in connection with the growing of sweet clover is recommended. It appears from the chemical data that the type is low in the various elements of plant food. Altho no data from field experiments are at hand, it seems probable that phosphorus in the form of bone meal or acid phosphate would prove beneficial for wheat and that corn would respond to the application of a potassium salt.

Brown-Gray Clay Loam On Tight Clay (1122.1)

An area of about one square mile of Brown-Gray Clay Loam On Tight Clay occurs four miles northwest of Gardner. It is similar to Brown Silt Loam On Tight Clay excepting that it is a clay loam instead of a silt loam. The topography is flat, being very similar to that of Black Clay Loam.

The surface soil is 8 to 12 inches deep. It varies from a brown silty clay loam to a clay loam that, when dry, has a gray appearance. It is fairly well supplied with organic matter. The subsurface soil, found at a depth of about 8 to 12 inches, is 4 to 10 inches thick and varies from a yellowish brown to a grayish brown or drab color. It becomes grayer and more drabbish in color, and heavier in texture, with increasing depth. The subsoil is found at a depth of 12 to 22 inches, and is a drab to grayish yellow, compact clay, very impervious to water. The chemical analysis of the sample collected reveals the unusually high sulfur content of 16,680 pounds per acre in the lower sampling stratum (20 to 40 inches). This is probably due to an accumulation of gypsum.

Management.—The management of this type should be about the same as that recommended for Brown Silt Loam On Tight Clay described above, except that there is even greater necessity for the maintenance of the organic matter to keep the soil in good tilth. This type shows only slight acidity in the surface soil; however, if sweet clover is to be grown, an application of about 2 tons of ground limestone per acre is advised.

Brown Sandy Loam On Gravel (1160.4)

A small area of Brown Sandy Loam On Gravel occurs in the northeastern part of the county along Aux Sable creek. It covers only 32 acres. The surface stratum is 8 to 10 inches deep. It is a brown sandy loam, fairly well supplied with organic matter. The subsurface is of about the same character as the surface stratum, except that it contains some gravel. At a depth of 22 to 26 inches, gravel constitutes the soil material.

Management.—The presence of considerable limestone close to the surface indicates that the application of this material is not necessary. In other particulars, the management should be about the same as that of Brown Sandy Loam (1160). Early maturing crops should be grown on account of the nearness of the gravel to the surface and the consequent liability to summer drouth.

(b) UPLAND TIMBER SOILS

The upland timber soils occur as irregular zones along streams and on or near somewhat steep morainal ridges. They are characterized by a yellowish gray color, due to their low organic-matter content. The deficiency of organic matter has been caused by the long-continued growth of forest trees. After the forest invaded the prairies, two effects were produced: first, the shade from the trees prevented the growth of prairie grasses, the roots of which are mainly responsible for the large organic-matter content in prairie soils; second, the trees themselves added very little organic matter to the soil, for the leaves and branches either decayed completely or were burned by forest fires. Furthermore, the organic matter that had been produced by the prairie grasses became gradually dissipated during the occupation of the land by the trees. As a result, the organic-matter content of the upland timber soils has been reduced until it is decidedly lower than that of the adjacent prairie land. Several generations of trees were necessary to produce the present condition of the soil.

The upland timber soils of Grundy county cover 12.81 square miles, or 3 percent of the entire area of the county.

Yellow-Gray Silt Loam (934, 1034, 1134)

Yellow-Gray Silt Loam occurs in the vicinity of the Illinois river and its tributaries. There is also an area in the northeastern part of the county on the steeper part of the Minooka ridge near the DuPage river. The type covers 7.65 square miles, or 1.79 percent of the area of the county. In topography it is sufficiently rolling for fair surface drainage without much tendency to wash if proper care is taken.

The surface, which is 7 to 8 inches deep, is a yellowish gray to grayish brown, or gray silt loam. The more nearly level areas are gray or grayish brown in color, while the more rolling phase of the type is yellowish-gray or brownish yellow. As the type approaches Brown Silt Loam, it becomes decidedly darker. The organic-matter content is low. The subsurface stratum varies considerably in thickness. On the more rolling parts, it rarely exceeds 5 inches in thickness, while on the more level areas it varies from 8 to 14 inches. It is usually a gray, grayish yellow, or yellow, silt loam, or sandy silt loam. The subsoil, which begins at a depth of 10 to 22 inches, is a mottled yellow sandy clay, silty clay, or clay, somewhat plastic when wet, but friable when only moist. It is pervious to water. The subsoil varies in physical composition even more than does the surface stratum. Frequently boulder clay constitutes part or all of the subsoil. Sometimes sand may be encountered at a depth of 30 to 40 inches. The sand was deposited by the wind previous to the deposition of the loess which constitutes most of the soil material of the upland in Grundy county.

This type drains well except on some of the more level and older forested areas, where a rather compact subsoil has developed that retards the movement of water.

Management.—In the management of Yellow-Gray Silt Loam, it is very necessary to maintain and even to increase the organic-matter content. This is necessary in order to supply nitrogen, to liberate mineral plant foods, to give

the soil better tilth, to prevent running together during heavy rains, and to prevent erosion on the more rolling phase. Rotations should be practiced that for a time at least will keep the soil in pasture, clover, or alfalfa, and will reduce the tilled crops to a minimum acreage.

The type in this county varies somewhat with respect to limestone content. In some localities considerable quantities of limestone are found in the lower sampling stratum, while in other places the reaction is distinctly acid. In planning the improvement of this soil, therefore, it is well to apply the acidity tests described in the Appendix, page 44. In case limestone is needed for the growth of legumes, an initial application of 2 to 3 tons of limestone per acre is advised. Subsequent applications of 1 to 2 tons per acre should be made when the need for it begins to be apparent. The surface soil of this type is low in phosphorus; however, the phosphorus content to a depth of 40 inches exceeds that of Brown Silt Loam. Experiment field results indicate that steamed bone meal can be used at a profit on the type. The use of acid phosphate would also be expected to be profitable. While no experiment field results with rock phosphate which are applicable to this type in Grundy county are available, it is reasonable to suppose that the use of this material, if properly applied, would prove profitable. (See account of Antioch experiment field in the Supplement, page 63.)

Yellow Silt Loam (935, 1035, 1135)

Yellow Silt Loam is an unimportant type in Grundy county because of its small area. There are only 4.28 square miles in the entire county.

The character of this type varies greatly, owing to differences in rate of erosion which are caused chiefly by differences in slope. The surface soil is usually a yellow or grayish silt loam. It may be a yellow clay or even gravel, depending on the amount of erosion. Till is commonly found at 40 inches or less in depth.

Management.—Fortunately but little of this land is under cultivation. It should be kept in permanent pasture or in timber. The surface is usually slightly acid, but carbonate is always found at less than 40 inches, frequently at a depth of 12 to 14 inches. Good pasture may be provided by applying about two tons of limestone per acre and seeding sweet clover. Alfalfa is also a good crop for this land after limestone has been applied.

Yellow-Gray Sandy Loam (1064, 1164)

Five hundred and twelve acres of Yellow-Gray Sandy Loam are found in Grundy county. It occurs, for the most part, along the Mazon river, east and north of Mazon.

The surface is 6 to 7 inches deep and is a grayish yellow sandy loam, low in organic matter. The subsurface, which extends to a depth of 18 to 20 inches, varies in color from gray to yellow and in texture from sand to sandy clay. The subsoil varies from a yellow sand to yellow sandy clay.

Management.—This type is usually slightly acid in the surface, but contains large amounts of carbonate at a depth of 30 to 40 inches. For the growth of legumes, 2 tons of limestone per acre should be sufficient for the initial applica-

tion. Presumably, beneficial results would be obtained from the application of bone meal or of acid phosphate.

Dune Sand (1181)

There are only 51 acres of Dune Sand of the upland in Grundy county. Its origin, character, and management are so similar to Dune Sand of the terrace region that reference is made to that type. (See page 27).

(c) TERRACE SOILS

Terrace soils are formed on terraces or old fills in valleys. The terraces owe their formation generally to the deposition of material from overloaded streams which became greatly enlarged and which flooded the valleys during the melting of the glaciers. Sometimes these valleys were filled almost to the height of the upland. Later the streams cut down thru the fills and developed new bottom lands, or flood plains, at lower levels, leaving part of the old fills as terraces. The lowest and most recently formed bottom land is called first bottom. The higher land no longer flooded (or very rarely, at most) is generally designated as second bottom. Finer material later deposited on the sand and gravel of the fill constitutes the mineral portion of the soil. Along some of the streams the fill seems to have been made almost entirely of fine, silty material.

Brown Silt Loam (1526)

The Brown Silt Loam of the terrace occurs mainly along the north side of the Illinois river, and in the north half of Township 33 North, Range 8 East (Gooselake). South of this only a few small patches are found scattered in the extensive sand area. In topography the type is flat to slightly undulating, the difference in elevation being due very largely to former channels or old bayous that have become partly filled by sediment. This type is not generally underlain by gravel or sand. In the area south of the river, large numbers of boulders are scattered over the land, frequently in such abundance as to make the land of value for pasture only. In many places these boulders have been removed from the fields and piled along fences; thus some excellent farming land has been reclaimed. The area north of the river does not contain so many of these boulders. The total area of the type is 17.82 square miles, or 4.17 percent of the total area of the county.

The surface is 9 to 10 inches deep and varies in color from light brown to black and in texture from a sandy loam to a heavy silt loam. The subsurface extends to a depth of 15 to 20 inches and varies from a yellowish brown silt loam to a yellow, mottled clay loam. The subsoil is usually bright yellow in color and a clay loam or a sandy clay loam in texture. It is not unusual to strike the bed rock at 30 inches and frequently it is encountered at 20 inches over small areas.

Management.—This type varies in regard to acidity. In other respects it is so similar to the Brown Silt Loam of the upland that reference is made to the management recommended for that type (see page 16).

Black Clay Loam (1520)

Black Clay Loam, Terrace, is found principally along the Illinois river, where it is associated with Brown Silt Loam. A few small areas occur in the midst of the sandy soils of the broad terrace in the eastern part of the county. The topography varies from flat to slightly undulating. The areas north of the river appear to have been formed under conditions of better drainage than those south of the river.

The surface, which is about 9 inches deep, is a black clay loam over most of the area. The subsurface varies considerably in depth, in some areas extending to the till with no subsoil development while in others it is very thin. However, it is uniformly a pale yellow or yellowish brown, mottled, silty clay loam. The subsoil is found at depths varying from 10 to 20 inches, depending upon the development of the subsurface stratum. It consists of a dark yellow, slightly mottled clay, or of till.

South of the river the surface to a depth of 8 to 12 inches is a black to drab clay loam. The subsurface, which extends to a depth of 14 to 22 inches, is a drab clay loam. The subsoil is variable in texture and color, but over a large portion of the area, is a bluish drab clay.

Management.—This type does not need limestone for the most part, altho north of the river there are small areas which test acid. The subsoil thruout the type contains carbonates. South of the river some areas are distinctly alkaline, tho probably never sufficiently so to be harmful. The important requirement in the management of this type is to improve the drainage on areas which are not now well drained and to make provision for returning fresh organic matter as a means of maintaining a condition of good tilth.

Brown Sandy Loam (1560)

Brown Sandy Loam occurs principally in a large body in the eastern part of the county and represents a wide terrace extending into this county from Kankakee and Will counties. This terrace was formed by the Glacial Kankakee river. The type covers 49.45 square miles, or more than one-tenth of the area of the county. The topography is mostly flat with occasional undulations produced by dunes that have been covered by fine material. These slight elevations constitute a slightly better phase than the flat, somewhat poorly drained areas.

The surface, which is about 8 inches deep, varies from a brown sandy silt loam to a sand. The subsurface is a yellowish brown to gray sandy loam varying in thickness from 6 to 20 inches with an average of about 14 inches. In the low, poorly drained areas, the soil frequently changes at a depth of 8 to 12 inches to a gray sandy loam a little coarser in texture than that on the low ridges. The subsoil, which begins at 14 to 28 inches, is usually yellow, grayish yellow, or gray in color and varies from a sand to a silty sand, with the sand predominating.

Management.—As a general rule, the drainage of the undulating phase of the type is fair, but in the flat phase, artificial drainage is necessary in many cases. Because of the perviousness of the strata, drainage takes place readily if a good outlet can be obtained. Some difficulty, however, is encountered in

the case of open ditches, which tend to fill up rapidly with sediment, and if tile is used, fine sand sometimes runs into the tile to a troublesome extent.

In the management of this type, it is very necessary that the organic-matter content be maintained. Crop residues, manure, and legumes should be turned under. The application of limestone is not usually necessary except on the higher areas. The type is low in phosphorus. On this very sandy soil so deficient in organic matter, it probably would be advantageous to use one of the more readily soluble forms of phosphate, such as bone meal or acid phosphate.

Yellow-Gray Silt Loam (1534)

Yellow-Gray Silt Loam, Terrace, comprizes about 2½ square miles, or .6 percent of the area of the county. The largest area of this type is in the northeast part of the county along Aux Sable creek. It is distributed in rather small isolated areas along the Illinois terrace and to some extent along Mazon river. The topography is slightly undulating, owing to the presence of old stream channels. There is no distinct layer of sand or gravel in the subsoil. Many boulders occur in this type.

The surface, which is 6 to 8 inches in depth, is a yellowish gray to grayish brown silt loam containing an appreciable amount of fine and medium sand. The organic-matter content is low. The subsurface varies greatly in thickness; in some areas it does not exceed 3 inches, while in others it is 10 or 12 inches thick. It is a grayish yellow silt loam, usually containing an appreciable amount of sand. The subsoil is a yellow or yellowish drab clayey silt loam or clay loam, with some gravel at 24 to 28 inches. Where gravel is encountered, strong effervescence with acid shows the presence of carbonate.

Management.—The type is low in nitrogen and in phosphorus in the surface soil; however, the phosphorus content to a depth of 40 inches compares very favorably with most of the other types in the county. Tests indicate lack of carbonate in the upper soil, but an abundance in the subsoil. An application of limestone of about 2 tons per acre, in order to insure the thrifty growth of legumes, is suggested as the first step towards more profitable production. Clovers, especially deep-rooting sweet clover, is an excellent crop for this type, and every means should be used to get the soil in condition for growing sweet clover. Experiment field results on a very similar type indicate that the available forms of phosphate can be used at a profit on this type of soil.

Yellow-Gray Sandy Loam (1564)

Yellow-Gray Sandy Loam occupies a large share of the terrace of the Mazon river. It covers an area of 1,338 acres, or .49 percent of the area of the county. In topography it resembles the Yellow-Gray Silt Loam just described.

The surface, which is 6 to 7 inches deep, is for the most part a grayish brown sandy loam, altho it varies from a sandy silt loam to a sand. The organic-matter content is low. The subsurface, extending to a depth of about 19 inches, is a yellowish gray sandy loam. The subsoil to a depth of 24 to 38 inches, is a yellowish gray sandy clay which then passes into a gray coarse sand.

Management.—This type requires approximately the same management as the preceding one, Yellow-Gray Silt Loam. It is, however, a poorer soil, and probably will not respond so satisfactorily to good treatment and management.

Brown-Gray Silt Loam On Tight Clay (1528)

The total area of Brown-Gray Silt Loam On Tight Clay, Terrace, in the county amounts to 205 acres. The largest area is in Sections 29 and 30, Township 33 North, Range 8 East (Gooselake). The topography of this type is flat and the presence of the tight clay subsoil hinders underdrainage very seriously.

The surface to a depth of about 8 inches is a grayish brown to brown silt loam, fairly well supplied with organic matter. The subsurface is a stratum of gray silt loam 3 to 6 inches in thickness. The subsoil found at a depth of 11 to 14 inches, is a gray to drabbish brown, plastic, impervious clay.

Management.—Two or three tons of limestone per acre should be applied. Sweet clover is recommended as a good legume to grow, for it furnishes a liberal supply of needed organic matter and nitrogen. Good surface drainage by means of open furrows should be provided for. While effective underdrainage is one of the greatest needs of this soil, as mentioned above, no practicable means is known of securing it.

Brown-Gray Sandy Loam On Tight Clay (1568)

Brown-Gray Sandy Loam On Tight Clay, Terrace, occurs almost entirely south of the Illinois river. It occupies only 134 acres. The topography is flat and the land is poorly drained.

The surface, which is 7 to 12 inches deep, is a brown sandy loam which, when dry after a rain, has a grayish appearance. It is low in organic matter. The subsurface, which extends to a depth of 20 to 40 inches, is a gray sandy loam. The subsoil is a dark yellowish drab to gray clayey sand, plastic and impervious.

Management.—In the management of this type, one of the first requirements after the drainage has been taken care of, as suggested for Brown-Gray Silt Loam On Tight Clay, Terrace, is the application of about 2 tons of limestone per acre in order to insure the successful growth of legumes. Sweet clover is recommended as a good legume for maintaining organic matter and nitrogen, and there is a possibility that its deep-rooting habit tends to open up the subsoil and promote better drainage. The chemical analysis indicates that this type is relatively low in the elements of plant food. No experimental results are available as to the treatment of this type; however, the known response of crops suggest the trying in an experimental way of a soluble phosphate for wheat, and a potash salt, either potassium chloride or sulfate, for corn.

Dune Sand (1581)

Dune Sand occurs principally in the sandy terrace south of the Illinois river. The topography is slightly undulating, there being no very high dunes

in this county as a general rule. There is a total of 6.62 square miles mapped as this type, or 1.55 percent of the area of the county.

The surface soil, to a depth of 8 or 10 inches, is a medium sand, mixed with some fine sand and a small amount of silt. It varies in color from yellow to light brown. It is very low in organic matter. There is no true subsurface and subsoil development. Below the surface a yellow color predominates to a depth of 20 to 30 inches, where it becomes drabbish yellow. There is but little change in texture with depth.

Management.—The sand in this county is better as a rule than most dune sand, owing to its finer texture. It contains more or less fine sand, as well as a slight amount of silt. It will, therefore, retain plant food, organic matter, and moisture better than the ordinary dune sand, and it is not so likely to drift.

This soil is extremely deficient in organic matter, nitrogen, and sulfur and is low in phosphorus. A program of improvement involves the liberal use of legumes, which, in connection with the use of phosphates in a readily available form, and potassium salts, would probably prove profitable. Carbonates appear to be lacking, so the first recommendation would be to apply 2 to 4 tons of limestone per acre, and then to grow legumes at every opportunity. Where these patches of dune sand are already wooded, it is advisable to retain them as permanent pasture rather than to attempt to cultivate them. (See account of Oquawka field, page 64 of the Supplement.)

Black Sandy Loam (1561)

Black Sandy Loam occurs in the sandy terrace area south of the Illinois river. The topography is flat and as a general rule the type is very poorly drained.

The surface, which is about 9 inches deep, is a black sandy loam varying toward a peaty loam in small areas. It is well supplied with the more inert forms of organic matter, but is generally deficient in the active forms. The subsurface to a depth of about 19 inches is a brownish black sandy loam. The subsoil is a yellow, grayish yellow, or brown sand which passes into a coarse gray sand at about 40 inches.

Management.—The first requirement of this type is drainage. Since all strata are pervious, underdrainage may be provided very readily if there is an adequate outlet. Alkali spots occur which may be corrected either by growing sweet clover frequently and turning it under or by applying potassium salts at regular intervals. It is an excellent plan to grow a legume in the rotation and turn it under as a source of readily decomposable organic matter and available nitrogen.

Brown Sandy Loam On Rock (1560.5)

Brown Sandy Loam On Rock is associated with Brown Silt Loam On Rock.

The surface soil is a brown sandy loam which varies in depth from 1 or 2 inches, where the rock comes near the surface, to 8 or 10 inches, where the rock lies at a depth of about 20 inches or more. This stratum is well supplied with organic matter. The subsurface soil is a yellow to brownish yellow sandy loam.

The depth of the sandstone or limestone bed rock determines the thickness of this stratum. It varies from 0 to 20 inches or more.

Management.—This is a very shallow soil and is consequently subject to drouth. It is somewhat better stocked with plant food than the average sandy loam, and is good pasture land, but it is unsuited to cropping over much of the area.

Brown Silt Loam On Rock (1526.5)

With the exception of a few small, isolated areas, Brown Silt Loam On Rock occurs in the northeast part of the county south of that part of the Illinois river where it bends abruptly southwest. The topography is undulating and there are occasional outcrops of limestone. A considerable portion of the area contains large glacial boulders in such abundance that it is not practicable to bring it under cultivation.

The surface, to a depth of about 8 inches, is a brown silt loam containing an appreciable amount of fine sand. The organic-matter content is high. The subsurface generally extends to limestone rock, which is usually found at depths varying from 11 to 20 inches, altho in some small spots the bare rock is exposed on the surface.

Management.—This soil is unusually rich in the plant-food elements and under favorable weather conditions is very productive. It is so shallow, however, that it does not resist drouth very well, and for this reason much of it is in pasture. If cropped at all, early maturing crops should be grown so that the greatest demand for moisture will come early in the season.

Brown Sandy Loam Over Gravel (1566)

Brown Sandy Loam Over Gravel occupies about one square mile. It is found just south of the junction of the Illinois and Mazon rivers. The topography is slightly undulating and the depressions probably represent old channels of rapid currents.

The surface to a depth of 8 or 9 inches is a brown sandy loam containing a considerable proportion of coarse sand. It is low in organic matter. The subsurface is found at about 9 inches in depth and varies from 4 to 10 inches in thickness. It is a light brown to yellowish brown sandy loam. The sand is coarse, similar to that of the surface. The subsoil is a yellow sandy loam containing coarse sand and some gravel. Rather pure gravel occurs at depths varying from 30 to 40 inches.

Management.—This type is low in nitrogen; consequently legumes should be grown at frequent intervals to increase the amount of organic matter and nitrogen. The surface soil of this type shows slight acidity, and for the best growth of alfalfa or sweet clover, about 2 tons of limestone per acre is recommended. The subsoil at a depth of 30 to 40 inches may contain large quantities of carbonates and when this is the case, it is likely that the initial limestone application will be sufficient for an unusually long period.

Yellow-Gray Sandy Loam On Gravel (1564.4)

The only area of Yellow-Gray Sandy Loam On Gravel in Grundy county occurs just across the river south of Stockdale. It is a small tract of only 64 acres. The topography is undulating.

The surface, which is about 7 inches deep, is a brownish gray sandy loam containing very coarse sand and some fine gravel. The subsurface varies in thickness from a very thin stratum to a maximum of about 8 inches, according to the depth of the gravel. It is ordinarily found at a depth of about 7 inches and is a yellow, very coarse, sandy loam containing some fine gravel. Practically pure gravel occurs at depths varying from 7 to 30 inches.

Management.—The type should receive practically the same management as Brown Sandy Loam On Gravel (1560.4), a discussion of which follows.

Brown Sandy Loam On Gravel (1560.4)

Brown Sandy Loam On Gravel occurs on both sides of the Illinois river, the largest areas being south of the river nearly opposite the town of Morris. The type covers an area of 1,792 acres, or .65 percent of the area of the county. The topography is undulating.

The surface, which is a brown sandy loam, varies greatly in depth. It sometimes extends to a depth of 14 or 15 inches where gravel is encountered. Ordinarily, however, it is 7 to 9 inches in depth and grades into a yellowish brown sandy loam subsurface. Below the subsurface, beginning at a depth of 14 to 20 inches, gravel with a high carbonate content is encountered. The gravel is nearer the surface on the higher parts; in the lower places the soil is darker and the gravel may lie as much as 36 inches beneath the surface, altho these areas are usually not large enough to be indicated on the map.

Management.—The fact that the stratum of soil above the gravel is rather thin accounts for the drouthy nature of this type. The growing of legumes is advised. The use of early maturing crops is also desirable, in order that the period of the greatest need of moisture by the crop will be past before the driest part of the season approaches.

(d) LATE SWAMP AND BOTTOM-LAND SOILS

In the group designated as late swamp and bottom-land soils are included the bottom lands or flood plains along streams, the swamps, the poorly drained lowlands, and also all peats and mucks, whether on upland or terrace. Much of the soil is of alluvial formation, and the land is largely subject to overflow. A large part of the county was entered in the government records as swamp land, but these former swamps are, for the most part, now sufficiently well drained to produce excellent crops. There is some of this land, however, that needs more drainage. The total area in the county classed here as swamp and bottom land amounts to 27.37 square miles, or 6.4 percent of the area of the county.

Deep Brown Silt Loam (1426)

Deep Brown Silt Loam occurs extensively along the Illinois river as well as along some of the smaller streams. The topography is flat to slightly undulating, the undulations being caused by overflow channels or by abandoned stream courses.

The surface is 10 to 14 inches in depth. It varies from a clayey silt loam to a sandy loam, and generally contains a considerable percentage of sand. It is well supplied with organic matter. The subsurface is slightly lighter in color than the surface and passes into a yellowish drab colored subsoil at 18 to 30 inches.

Management.—Practically all of the type is subject to overflow. The sediment deposited during each overflow period maintains a good supply of plant-food elements. Good cultivation, then, is the principal factor for consideration in the management of this type.

Mixed Loam (1454)

Mixed Loam occurs as bottom land along the small streams, principally in the central part of the county. It usually takes the form of narrow strips which are rarely more than a quarter of a mile wide.

This type is in reality a mixture of types, as its name implies; black clay loam, brown silt loam, brown loam, brown sandy loam, and even sand may all be found. Even if it were possible to indicate on the map the many variations, the effort would be useless because the next flood would probably leave a different mixture. Since this type as mapped is a mixture of a number of types, it is impossible to write a description of it which will apply to the type as a whole. For the same reason, no attempt is made to show chemical composition in the tables of plant-food elements. The same management is required as that advised for Deep Brown Silt Loam.

Black Clay Loam (1420)

Black Clay Loam, Bottom, occurs in the Illinois river bottom, near the junction of Aux Sable creek and the Illinois river. It is flat in topography and is subject to overflow.

The surface, which is about 8 inches deep, is a black, plastic, granular, heavy clay loam. The subsurface is 4 to 10 inches in thickness. It is usually drabbish in color and is slightly heavier than the surface soil. The subsoil, which begins at 12 to 20 inches, is a drab or grayish drab, heavy, plastic clay.

Management.—Drainage is the first requirement of this type, but draining is usually very difficult, not because of the impervious character of the soil, but on account of the difficulty of obtaining a good outlet. Because of its heavy character it is necessary that this soil be kept well supplied with organic matter in order to help in the maintenance of a good physical condition. Limestone is not needed.

Brown Sandy Loam (1460)

Brown Sandy Loam occurs in the bottom lands of the Illinois river, fairly well distributed thruout this area. The topography is flat to slightly undulating.

The surface, 8 to 12 inches in depth, is, for the most part, a brown sandy loam, but varies toward a silt loam on the one hand and toward a sand on the other. It is fairly well supplied with organic matter. This type, in common with other bottom-land types, shows no development of distinct subsurface and subsoil strata. At a depth of 8 to 12 inches the color becomes lighter, and gravel is frequently found at a depth of 16 to 20 inches.

Management.—Practically all of this type is subject to overflow and thus the soil receives a deposit which helps to maintain the supply of plant-food elements. The drainage of the lower and flatter areas is a difficult problem, altho as a general rule this type is the higher part of the overflow bottoms along the Illinois river. Another difficulty with this type is that some areas where the sand is coarse are subject to drouth. Good cultivation is the important part of the management of this type. The surface soil of some portions of the area is slightly acid; however, since carbonate is usually found within 20 inches of the surface and the land is subject to overflow, it is probably not necessary to apply limestone. In case overflow prevents the growing of biennial and perennial legumes, such as the clovers and alfalfa, then the frequent use of annuals, such as cowpeas and soybeans, is advised. Legumes of any kind plowed under directly as green manure ought to prove especially beneficial to the crops that follow.

Black Mixed Loam (1450)

Black Mixed Loam occurs in the bottom land of the Illinois river both on the north and the south sides of the stream. Boulders are scattered pretty generally over the surface of this type.

The surface soil varies in texture from clay loam to sandy loam and may contain spots that are peaty in character. The organic-matter content is also extremely variable. These differences, together with similar subsurface and subsoil differences, occur in such small areas that type separations cannot be made.

Management.—The first requirement of this type is drainage. Draining is frequently difficult because of the lack of an outlet and also because of the fact that the land is often flooded. The soil is, however, very productive. There are small areas of alkali. The growing of sweet clover will do much to counteract the harmful effect of the alkali. Much of the Black Mixed Loam is not cultivated but is left in pasture, principally because of the fact that it cannot be drained satisfactorily.

Peaty Loam On Clay (1410)

The area mapped as Peaty Loam On Clay occurs in the bottom lands of the Illinois river in the northwest part of Township 33 North, Range 8 East (Gooselake). It is subject to overflow from the river.

This area varies from Peaty Loam On Sand or Peaty Loam On Clay around the edges to Deep Peat thru the center. It is high in inert, well decomposed,

organic matter. Alkali is present over much of the area in sufficient amount to be harmful.

Management.—Drainage is the first requirement. The application of potassium would probably be beneficial in helping to overcome the effect of the alkali on the growing crop even tho it, as well as all of the other elements of plant food, is naturally present in abundance.

Medium Peat On Clay (1402)

A small area of Medium Peat On Clay occurs in the vicinity of Peaty Loam On Clay. The land is very low and swampy and is subject to overflow in time of medium high water.

The surface, 12 to 16 inches in depth, is a black, well-decomposed peat. A stratum of dark yellow, strongly mottled, silty clay loam is then found to a depth of about 30 inches, at which point peat again occurs and extends to a depth of 7 feet or more.

Management.—Drainage is the first requirement of the type. Potassium is deficient in the surface sample (0 to 6⅔ inches); however, it is abundant in the 40-inch section. Phosphorus is deficient in the first 20 inches. The presence of alkali in this area suggests that potassium might be beneficial. Experimental results in other states indicate that on a soil of this character phosphates are beneficial.

Deep Peat (1401)

A few areas of Deep Peat occur in the bottom land of the Illinois river. Another one occurs in Township 33 North, Range 8 East, and occupies a part of an area that was formerly known as Goose Lake, but which has recently been drained and is now under cultivation.

The soil is a black, well decomposed peat to a depth of 30 to 40 inches. Below this depth a varying amount of coarse sand is mixed with the peat.

Management.—Drainage is the first requirement. In the installation of the drains a difficulty is met in the case of tile drainage, because the loose character of the peat makes it difficult to hold the tile in line. This trouble may be overcome by putting boards in the bottom of the ditch and laying the tile on the boards. Peat is usually deficient in the element potassium and it has been found to be profitable to supply that element in amounts of 100 to 200 pounds or more of potassium salts per acre for the corn crop. The type is always well provided with nitrogen. A considerable portion of the Goose Lake area has been burned over and its nature thus changed. Large boulders are found over portions of this area. No experimental data are available regarding the treatment of these burned over areas, but it is not likely that potassium salts are required on them. (See account of Manito experiment field, page 66 of the Supplement.)

Muck On Clay (1413)

Muck On Clay is found in a long, narrow depression south of the river just across from Morris, and in a small area in Section 23, Township 31 North, Range 6 East (Highland).

The surface, 8 to 12 inches in depth, is a black, granular muck. This passes into black clay which extends below the 40-inch depth examined.

Management.—Drainage is the first requirement, and this, followed by good cultivation, is practically all that will be necessary for a long period of time before any fertilization will be needed.

Muck On Marl (1413.6)

Muck On Marl occurs only in one area, 6 acres in extent, in Section 30, of Good Farm township (Township 31 North, Range 7 East).

The soil to a depth of about 10 inches is a very heavy black muck, granular and somewhat plastic when very wet. It passes into a black clay loam which rests on marl at a depth of about 20 inches. The marl extends to a depth of about 60 inches, at which point highly calcareous, coarse, gray sand is encountered.

Management.—The type needs drainage and good cultivation. Analysis shows the marl to contain about 53 percent calcium carbonate equivalent.

(e) RESIDUAL SOILS

Residual soils are formed from the residue left in place by the weathering of rock and the accumulation of organic matter. Such soils are found in the valley of the Illinois river where the former stream has swept all the glacial material from the rock leaving it exposed. This rock was a shaly sandstone which weathers readily, and to a depth of 10 to 28 inches it has decomposed into soil material.

Brown Sandy Loam On Rock (060.5)

Brown Sandy Loam On Rock occurs principally in the western part of the county. It covers an area of 857 acres, or .31 percent of the area of the county. The topography is flat to slightly undulating.

The surface, which is about 8 inches deep, is a brown to dark brown sandy loam and contains a few fragments of the shaly sandstone rock from which it was derived. Glacial boulders are found in abundance in the surface soil over portions of the area. It is well supplied with organic matter. The subsurface varies from 10 to 18 inches in thickness and is a yellowish brown or yellowish gray silty sand containing fragments of the shaly sandstone. The sandstone rock which is found at a depth of 18 to 26 inches is so thoroly weathered that it may be penetrated by the auger without a great deal of difficulty.

Management.—Residual Brown Sandy Loam On Rock is not a very good type of soil. It is generally strongly acid and the first requirement in building up this type is an application of 2 or 3 tons of limestone per acre. Crop residues, farmyard manure, and legumes should be turned under. In favorable seasons this soil would probably respond to phosphorus and potassium treatment; however, because of the shallowness of the soil, successful cropping is likely to be uncertain. If the land is cultivated, it is advisable to raise early maturing crops. It probably would be safer to continue using this type mainly as pasture land, as much of it is now used.

Yellow-Gray Sandy Loam On Rock (064.5)

Yellow-Gray Sandy Loam On Rock occurs in the same locality as the preceding type but in much smaller area. There are only 128 acres. This land is slightly undulating.

The surface, which is 6 to 8 inches deep, is a light brown to yellowish gray sandy loam containing fragments of the original rock. It is deficient in organic matter. The subsurface soil varies in depth according to the distance to rock and this varies roughly from 7 to 30 inches. The soil material is a yellow to gray sandy loam and in the extreme may even vary to a sand. The shaly sandstone is rather rotten and it is not difficult to dig ditches for drainage purposes. In this, as well as in the preceding type, large numbers of glacial boulders are present.

Management.—This type, while it is much lower in nitrogen and organic matter than Brown Sandy Loam On Rock, is a better soil, judging from its native vegetation. It does not test acid as does the corresponding prairie type (1164.5). Excepting for the limestone recommendation, the same management is advised as for Brown Sandy Loam On Rock (060.5).

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to intelligently interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification used.

The type is the unit of classification and each type has definite characteristics. In establishing types, the following factors are taken into account: the character of the horizons composing the soil as to depth and thickness, physical composition, structure, organic-matter content, color, reaction, and carbonate content; the topography; the native vegetation; and the geological origin of the soil.[1]

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made whenever the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

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[1] Since some of the terms used in designating the factors which are taken into account in establishing soil types are technical in nature, the following explanations are introduced:

Horizon. A layer or stratum of soil which differs discernibly from those adjacent in color, texture, structure, chemical composition, or a combination of these characteristics, is called an horizon.

Depth and Thickness. The horizons or layers which make up the soil profile vary in depth and thickness. These variations are distinguishing features in the separation of soils into types.

Physical Composition. The physical composition, sometimes referred to as "texture," is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents: clay, silt, fine sand, sand, gravel, stones, and organic material.

Structure. The term "structure" has reference to the aggregation of particles within the soil mass and carries such qualifying terms as open, granular, compact.

Organic-Matter Content. The organic matter of soil is derived mainly from plant tissue and it exists in a more or less advanced stage of decomposition. Organic matter constitutes the predominating constituent in certain soils of swampy formation.

Color. Color is determined to a large extent by the proportion of organic matter, but at the same time it is modified by the mineral constituents, especially by iron compounds.

Reaction. The term "reaction" refers to the chemical state of the soil with respect to acid or alkaline condition. It also involves the idea of degree, as strongly acid or strongly alkaline.

Carbonate Content. The carbonate content has reference to the calcium carbonate (limestone) present, which in some cases may be associated with magnesium or other carbonates. The depth at which carbonates are found may become a very important factor in determining the soil type.

Topography. Topography has reference to the lay of the land, as level, rolling, hilly, etc.

Native Vegetation. The vegetation or plant growth before being disturbed by man, as prairie grasses and forest trees, is a feature frequently recognized in determining soil types.

Geological Origin. Geological origin involves the idea of character of rock materials composing the soil as well as the method of formation of the soil.

Classifying Soil Types.—In the system of classification used, the types fall first into four general groups based upon their geological relationships; namely, upland, terrace, swamp and bottom land, and residual. These groups may be subdivided into prairie soils and timber soils, altho as a matter of fact this subdivision is applied in the main only to the upland group. These terms are all explained in the foregoing part of the report in connection with the description of the particular soil types.

Naming and Numbering Soil Types.—In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a more or less definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise types names which are adequately descriptive, because the profile of mature soils is usually made up of four or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "on," and when its depth exceeds 30 inches, by the word "over"; for example, Brown Silt Loam On Gravel, and Brown Silt Loam Over Gravel.

As a further step in systematizing the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been assigned an index number. The names of the areas together with their general location and their corresponding index numbers are given in the following list.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* comprizing three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciations
300 *Lower Illinoisan glaciation,* covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* found in the older or Illinoisan glaciation
1400 *Late river-bottom and swamp lands,* those of the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan

For further information regarding these geological areas the reader is referred to the general map published in Bulletins 123 and 193.

Another set of index numbers is assigned to the classes of soils as based upon physical composition. The following list contains the names of these classes with their corresponding index numbers.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the balance of the number designates the type. To illustrate: the number 1126 means Brown Silt Loam in the early Wisconsin glaciation, 434 means Yellow-Gray Silt Loam of the middle Illinoisan glaciation. These numbers are especially useful in designating very small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports in connection with the maps.

SOIL SURVEY METHODS

Mapping of Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. The field work is done by parties of two to four men each. The field season extends from early in April to Thanksgiving. During the winter months the men are engaged in preparing a copy of the soil map to be sent to the lithographer, a copy for the use of the farm adviser until the printed map is available, and a third copy for use in the office in order to preserve the original official map in good condition.

An accurate base map for field use is necessary for soil mapping. These maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as the basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil type boundaries, together with the streams, roads, railroads, canals, town sites, and rock and gravel quarries are placed in their proper location upon the map while the mapper is on the area. With the rapid development of road improvement during the past few years, it is almost inevitable that some recently established roads will not appear on the published soil map. Similarly, changes in other artificial features will occasionally occur in the interim between the preparation of the map and its publication. The detail or minimum size of areas which are shown on the map varies somewhat, but in general a soil type if less than five acres in extent is not shown.

A soil auger is carried by each man with which he can examine the soil to a depth of 40 inches. An extension for making the auger 80 inches long is taken

by each party, so that the deeper subsoil may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by a speedometer or other measuring device, while distances in the field away from the roads are measured by pacing.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. The samples for this purpose are usually taken in three depths; namely, 0 to 6⅔ inches, 6⅔ to 20 inches, and 20 to 40 inches, as explained in connection with the discussion of the analytical data on page 8.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. A fact of equal importance, not so generally recognized, is that they also differ in other characteristics such as response to fertilizer treatment and to management.

The soil is a dynamic, ever-changing, exceedingly complex substance made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, the soil cannot be considered as a reservoir into which a given quantity of an element or elements of plant food can be poured with the assurance that it will respond with a given increase in crop yield. In a similar manner it cannot be expected to respond with perfect uniformity to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance favorable for the growth of the higher plants and of the beneficial microorganisms. Good soil management under humid conditions involves the adoption of those tillage, cropping, and fertilizer treatment methods which will result in profitable and permanent crop production on the soil type concerned.

The following paragraphs are intended to state in a brief way some of the principles of soil management and treatment which are fundamental to profitable and continued productivity.

CROP REQUIREMENTS WITH RESPECT TO PLANT-FOOD MATERIALS

Ten different elements of plant food are essential for the growth and formation of every plant. These elements are: *carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, magnesium, calcium, and iron.* Some seasons in central Illinois are sufficiently favorable to allow the production of at least 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. When such crops, growing under favorable climatic and cultural conditions and uninjured by disease or insect pests, are not produced the failure is due to unfavorable soil condition, which may result from poor drainage, poor physical condition, or from an actual deficiency in one or more of the elements of plant food.

TABLE A.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain.....	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain.......	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover......	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs........	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain.......	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw........	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed.......	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay.......	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed.....	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay.....	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay.......	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1]These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

Table A shows the requirements of some of our most common field crops with respect to the seven plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of any element removed from an acre of land by a crop of a given yield can easily be computed.

SUPPLY OF PLANT-FOOD ELEMENTS

Of the ten elements of plant food, three (*carbon, oxygen,* and *hydrogen*) are secured from air and water, and seven from the soil. *Nitrogen,* one of these seven elements obtained from the soil by all plants, may also be secured from the air by the class of plants known as legumes, in case the amount liberated from the soil is insufficient; but even these plants, which include only the clovers, peas, beans, and vetches among our common agricultural plants, are dependent upon the soil for the other six elements (phosphorus, potassium, magnesium, calcium, iron, and sulfur), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to nearly 33,000 pounds. In like manner the phosphorus content varies from about 420 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor

TABLE B.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	...	...
Sodium nitrate	310	...	...
Ammonium sulfate	400	...	...
Raw bone meal	80	180	...
Steamed bone meal	20	250	...
Raw rock phosphate	...	250	...
Acid phosphate	...	125	...
Potassium chlorid	...	...	850
Potassium sulfate	...	...	850
Kainit	...	...	200
Wood ashes[3] (unleached)	...	10	100

[1]See footnote to Table A.
[2]Young second year's growth ready to plow under as green manure.
[3]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

of production, then we must look for some outside source of supply. Table B is presented for the purpose of furnishing information regarding the quantity of some of the more important plant-food elements contained in materials most commonly used as sources of supply.

LIBERATION OF PLANT-FOOD ELEMENTS

The chemical analysis of the soil gives the invoice of plant-food elements actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such elements as calcium and phosphorus, converting them into available forms for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral elements are liberated for

the benefit of the cereal crops which follow in the rotation. Moreover, as an effect of the deep-rooting habit of these legumes, mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and supplies calcium, thus encouraging the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the unavailable organic nitrogen into available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium compounds.

Organic Matter and Biological Action.—Organic matter may be supplied thru animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant-food materials than the 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the ratio of carbon to nitrogen. Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing available phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant-food elements by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant-food materials are concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than

this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter, and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement.

Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands. Remarkable success has been experienced with limestone used in conjunction with sweet clover in the reclamation of abandoned hill land which had been ruined thru erosion.

Amounts to Apply.—If the soil is acid, usually at least 2 tons per acre of ground limestone should be applied as an initial treatment. Continue to apply limestone from time to time according to the requirement of the soil as indicated by the tests described below, or until the most favorable conditions are established for the growth of legumes, using preferably at times magnesian limestone ($CaCO_3MgCO_3$), which contains both calcium and magnesium and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone ($CaCO_3$). On strongly acid soils, or on land being prepared for alfalfa, 4 or 5 tons per acre of ground limestone may well be used for the first application.

How to Ascertain the Need for Limestone.—One of the most reliable indications as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover and alfalfa. These crops do not thrive in acid soils. Their successful growth, therefore, indicates the lack of sufficient acidity in the soil to be harmful. In case of their failure to grow the soil should be tested for acidity as described below. A very valuable test for ascertaining the need of a soil for limestone is found in the potassium thiocyanate test for soil acidity. It is of value to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonate of calcium and magnesium. The natural occurrence of these carbonates in the

soil is sufficient assurance that no limestone is needed, and the acidity test will be negative. On lands which have been treated with limestone, however, the surface soil may give a positive test for carbonates, due to the presence of undecomposed pieces of limestone, and at the same time a positive test for acidity may be secured. Such a result means either that insufficient limestone has been added, or that it has not been in the soil long enough to entirely correct the acidity. In making these tests, it is desirable to examine samples of soil from different depths, since carbonates may be present, even in abundance, below a surface stratum that is acid. Following are the directions for making the tests:

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol (not denatured). When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. In testing, therefore, the sample should be about as dry as when the soil is in good tillable condition. The conditions for a prompt reaction require a temperature that is comfortably warm.

The Hydrochloric Acid Test for Carbonates. Make a shallow cup of a ball of soil and pour into it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence, and indicates that the soil contains limestone or some other carbonate. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen usually costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for plant growth. These are the chemical and the biological fixation of the atmospheric nitrogen. Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of those legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for feed and seed as well as for fixing atmospheric nitrogen, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen will ever be able to replace the simple method

of obtaining atmospheric nitrogen by growing inoculated legumes in the production of our great grain and forage crops.

It may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpea hay contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of the soil is dependent upon the origin of the soil. The removal of phosphorus by continuous cropping slowly reduces the amount of this element in the soil available for crop use, unless its addition is provided for by natural means, such as overflow, or by agricultural practices, such as the addition of phosphatic fertilizers and rotations in which deep-rooting, leguminous crops are frequently grown.

It should be borne in mind in connection with the application of phosphate, or of any other fertilizing material, to the soil, that no benefit can result until the need for it has become a limiting factor in plant growth. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different materials containing phosphorus which are applied to land as fertilizer. The more important of these are bone meal, acid phosphate, natural raw rock phosphate, and basic slag. Obviously that carrier of phosphorus which gives the most economical returns, as considered from all standpoints, is the most suitable one to use. Altho this matter has been the subject of much discussion and investigation the question still remains unsettled. Probably there is no single carrier of phosphorus that will prove to be the most economical one to use under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

Bone meal, prepared from the bones of animals, appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the

phosphorus, a considerable percentage of nitrogen which adds a useless expense if the material is purchased only for the sake of the phosphorus. As a source of phosphorus, steamed bone meal is preferable to raw bone meal. Steamed bone meal is prepared by extracting most of the nitrogenous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate containing about 10 to 12 percent of the element phosphorus.

Acid phosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. Acid phosphate also contains besides phosphorus, sulfur, which is likewise an element of plant food. The phosphorus in acid phosphate is more readily available for absorption by plants than that of raw rock phosphate. Acid phosphate of good quality should contain 6 percent or more of the element phosphorus.

Rock phosphate, sometimes called floats, is a mineral substance found in vast deposits in certain regions. The phosphorus in this mineral exists chemically as tri-calcium phosphate and a good grade of the rock should contain 12½ percent, or more, or the element phosphorus. The rock should be ground to a powder, fine enough to pass thru a 100-mesh sieve, or even finer.

The relative cheapness of raw rock phosphate, as compared with the treated or acidulated material, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in this form than in the form of acid phosphate, the ratio being, under the market conditions of the past several years, about 4 to 1. That is to say, under these market conditions, a dollar will purchase about four times as much of the element phosphorus in the form of rock phosphate as in the form of acid phosphate, which is an important consideration if one is interested in building up a phosphorus reserve in the soil. As explained above, more very carefully conducted comparisons on various soil types under various cropping systems are needed before definite statements can be given as to which form of phosphate is most economical to use under any given set of conditions.

Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag phosphate is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore it tends to influence the soil reaction.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating the phosphorus from raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using acid phosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount

to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, which are silt loams and clay loams, are well stocked with potassium, altho it exists largely in a slowly soluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be supplied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of common soils are concerned, that, with a few exceptions, the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part, perhaps, because the potassium removed in the crops is mostly returned in the manure if properly cared for, and perhaps in larger part because the decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no plant-food elements of value.

In considering the conservation of potassium on the farm it should be remembered that in average live-stock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in live-stock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by the actual crop requirements for plant food, magnesium and calcium are more limited in some Illinois soils than potassium. But with these elements we must consider also the loss by leaching.

The annual loss of limestone from the soil depends, of course, upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of lime materials from the soil, it is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

Limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur

in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply to conditions in Illinois.

Physical Improvement of Soils

In the management of most soil types, one very important matter, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, slightly retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is undergoing destruction during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is neccessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, corn stalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and corn stalks should be turned under, and not burned. There is considerable evidence indicating that on some soils undecomposed straw applied in excessive amount may be detrimental. Probably the best practice is to apply the straw as a constituent of well-rotted stable manure. Perhaps no form of organic matter acts more beneficially in producing good tilth than corn stalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of corn stalks is one and one-half times that of a ton of manure, and a ton of dry corn stalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the corn stalks during the winter and often rather late in the spring after the frost is out of the ground. This tramping by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too

late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The effect becomes worse if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including, for the reasons discussed above, a liberal use of legumes. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations, applicable to the corn belt, which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover), or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in live-stock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be seeded four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. Or, in some cases, it may become desirable to divide the acreage of small grain and grow in the same year more than one kind. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields on Soil Types Similar to those Occurring in Grundy County)

In the earlier reports of this series it was the practice to incorporate in the body of the report the results of certain experiment fields, for the purpose of illustrating the possibilities of improving the soil of various types. The information carried by such data must, naturally, be considered more or less tentative. As the fields grow older new facts develop, which in some instances may call for the modification of former recommendations. It has therefore seemed desirable to separate this experiment field data from the more permanent information of the soil survey, and embody the same in the form of a supplement to the soil report proper, thus providing a convenient arrangement for possible future revisions as further data accumulate.

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the summarized results from certain of these fields located on types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement

The soil experiment fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, live-stock farming and grain farming.

In the live-stock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in form of plant manures, including the plant residues produced, such as corn stalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It is the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the live-stock system.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a rather definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, the equivalent of 200 pounds of kainit. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

BROWN SILT LOAM

Several experiment fields have been conducted on Brown Silt Loam at various locations in Illinois. Those located at the University have been in operation the longest and they serve well to illustrate the principles involved in the maintenance and improvement of this type of soil.

The Morrow Plots

It happens that the oldest soil experiment field in the United States is located on typical Brown Silt Loam of the early Wisconsin glaciation, on the campus of the University of Illinois. This field was started in 1879 by George E. Morrow, who for many years was Professor of Agriculture, and these plots are known as the Morrow plots.

The Morrow series now consists of three plots divided into halves and the halves are subdivided into quarters. On one plot corn is grown continuously; on the second, corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904. Besides farm manure, phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. At the same time the rate of subsequent application of both forms of phosphorus was reduced to one-fourth the quantity, or to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per year. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre.

Table 1 gives the yearly records of the crop yields from the Morrow plots, and Table 2 presents the results in summarized form.

FIG. 1.—CORN ON THE MORROW PLOTS IN 1910

TABLE 1.—URBANA FIELD, MORROW PLOTS: BROWN SILT LOAM; PRAIRIE; EARLY WISCONSIN GLACIATION

Crop Yields in Soil Experiments—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
		Corn	Corn	Oats	Corn	Oats	Clover
1879–87	None	....	....	....	....	....	....
1888	None	54.3	49.5	....	....	48.6	....
1889	None	43.2	....	37.4	....	....	(4.04)
1890	None	48.7	54.3	....	....	....	(1.51)
1891	None	28.6	33.2	....	....	....	(1.46)
1892	None	33.1	....	37.2	70.2	....	....
1893	None	21.7	29.6	....	34.1	....	....
1894	None	34.8	....	57.2	....	65.1	....
1895	None	42.2	41.6	....	....	22.2	....
1896	None	62.3	....	34.5	....	....	....
1897	None	40.1	47.0	....	....	....	....
1898	None	18.1	....	....	....	....	....
1899	None	50.1	44.4	....	53.5	....	....
1900	None	48.0	....	41.5	....	....	....
1901	None	23.7	33.7	....	34.3	....	....
1902	None	60.2	....	56.3	....	54.6	....
1903	None	26.0	35.9	....	....	....	(1.11)
1904	None	21.5	....	17.5	55.3	....	....
1904	MLP	17.1	....	25.3	72.7	....	....
1905	None	24.8	50.0	....	....	42.3	....
1905	MLP	31.4	44.9	....	....	50.6	....
1906	None	27.1	....	34.7	....	....	(1.42)[1]
1906	MLP	35.8	....	52.4	....	....	(1.74)[1]
1907	None	29.0	47.8	....	80.5	....	....
1907	MLP	48.7	87.6	....	93.6	....	....
1908	None	13.4	....	32.9	....	40.0	....
1908	MLP	28.0	....	45.0	....	44.4	....
1909	None	26.6	33.0	....	....	....	(.65)[2]
1909	MLP	31.6	64.8	....	....	....	(1.73)[3]
1910	None	35.9	....	33.8	58.6	....	....
1910	MLP	54.6	....	59.4	83.3	....	....
1911	None	21.9	28.6	....	....	20.6	....
1911	MLP	31.5	46.3	....	....	38.0	....
1912	None	43.2	....	55.0	....	....	16.3[1]
1912	MLP	64.2	....	81.0	....	....	20.0[1]
1913	None	19.4	29.2	....	33.8	....	....
1913	MLP	32.0	25.0	....	47.8	....	....
1914	None	31.6	....	33.6	....	39.6	....
1914	MLP	39.4	....	58.2	....	60.4	....
1915	None	40.0	49.0	....	....	....	24.2[1]
1915	MLP	66.0	81.2	....	....	....	27.1[1]
1916	None	11.2	....	37.5	27.8	....	....
1916	MLP	10.8	....	64.7	40.6	....	....
1917	None	40.0	48.4	....	....	68.4	....
1917	MLP	78.0	81.4	....	....	86.9	....
1918	None	13.6	....	27.2	....	....	(2.58)
1918	MLP	32.6	....	59.3	....	....	(4.04)
1919	None	24.0	30.8	....	52.2	....	....
1919	MLP	43.4	66.2	....	70.8	....	....
1920	None	28.2	....	37.2	....	52.2	....
1920	MLP	54.4	....	51.6	....	69.7	....
1921	None	19.8	30.6	....	....	....	(.26)[4]
1921	MLP	42.2	68.4	....	....	....	(1.33)[5]
1922	None	24.6	....	39.3	49.2	....	....
1922	MLP	39.4	....	55.8	65.3	....	....
1923	None	15.0	17.2	....	....	53.4	....
1923	MLP	31.4	[redacted]	....	....	66.6	....

46.4

[1]Soybeans.
[2]In addition to the hay, .64 bushel of seed was harvested.
[3]In addition to the hay, 1.17 bushels of seed were harvested.
[4]In addition to the hay, .53 bushel of seed was harvested.
[5]In addition to the hay, .85 bushel of seed was harvested.

TABLE 2.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY
Average Annual Yields—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover
		16 crops	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
1888 to 1903	None........	39.7	41.0	44.0	48.0	47.6	(2.03)
		20 crops	*10 crops*	*10 crops*	*7 crops*	*7 crops*	*4 crops*
1904 to 1923	None........	25.5	36.5	34.9	51.1	45.2	(1.23)[1]
	MLP........	40.6	[redacted]	55.3	67.7	59.5	(2.21)[1]

[1]One crop of soybean hay included. 61.2

Summarizing the data from these Morrow plots into two periods with the second period beginning in 1904 when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the untreated continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oats production, while the averages for the three-year system show an increase in corn yield and decreases in oats and clover. Unfortunately the numbers of crops included in these last averages are too small to warrant positive conclusions.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

The Davenport Plots

Another set of plots on the University campus at Urbana, forming a more extensive series than the Morrow plots, but of more recent origin, are the Davenport plots. Here provision is made for each crop in the rotation to be represented every year. These plots were laid out in 1895, but special soil treatment was not begun until 1901. They now comprize five series of ten plots each, and each series constitutes a "field" in a crop rotation system.

From 1901 to 1911 three of the series were in a three-year rotation system of corn, oats, and clover, while the remaining two series rotated in corn and oats. In 1911 these two systems were combined into a five-series field, with a crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field. The alfalfa occupies one series during a rotation of the other four crops, shifting to another series in the fifth year, thus completing the cycle of all series in twenty-five years.

The soil treatment applied to these plots has been as follows:

Legume cover crops were seeded in the corn at the last cultivation on Plots 2, 4, 6, and 8, from 1902 to 1907, but the growth was small and the effect, if any, was to decrease the returns from the regular crops. Crop residues (**R**) have been returned to these same plots since 1907. These consist of stalks and straw, and all legumes except alfalfa hay and the seed of clover and soybeans. Beginning in 1918 a modification of the practice was made in that one cutting of the red clover crop is harvested as hay. In conjunction with these residues a catch crop of sweet clover grown with the wheat is plowed under.

Manure (**M**) was applied preceding corn, at the rate of 2 tons per acre per year in 1905, 1906, and 1907; subsequently as many tons have been applied as there have been tons of air-dry produce harvested from the respective plots.

Lime (**L**) was applied on Plots 4 to 10 at the rate per acre of 250 pounds of air-slaked lime in 1902, and 600 pounds of limestone in 1903. No further application was made until 1911, when the system of cropping was changed. Since that time applications of limestone have been made at the rate of one-half ton per acre per year.

Phosphorus (**P**) was applied on Plots 6 to 9 at the rate of 25 pounds per acre per annum in 200 pounds of steamed bone meal; but beginning with 1908 rock phosphate at the rate of 600 pounds per acre per annum was substituted for the bone meal on one-half of each of these plots. These applications continued until 1918 when adjustments were begun, first to make the rate of application of rock phosphate four times that of the bone meal, and finally to reduce the amounts of these materials to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per annum. The usual practice has been to apply and plow under at one time all phosphorus and potassium required for the rotation.

Potassium (**K**) has been applied on Plots 8 and 9 in connection with the bone meal and rock phosphate, at the yearly rate of 42 pounds per acre, and mainly as potassium sulfate.

On Plot 10 about five times as much manure and phosphorus are applied as on the other plots, but this "extra heavy" treatment was not begun until 1906, only the usual amounts of lime, phosphorus, and potassium having been applied in previous years. The purpose in making these heavy applications is to try to determine the climatic possibilities in crop yields by removing the limitations of inadequate amounts of the elements of plant food.

It will be observed that the applications described above provide for the two rather distinct systems of farming already described. *The grain system,* in which animal manure is not produced and where the organic matter is provided by the direct return to the soil of crop residues along with legumes, is exemplified in Plots 2, 4, 6, and 8; and the *live-stock system,* in which farm manure is utilized for soil enrichment, is represented in the corresponding Plots 3, 5, 7, and 9.

Table 3 shows a summary of the results obtained on the Davenport plots beginning with the year 1911, when the present cropping system was introduced.

When used in conjunction with phosphorus the crop residues and the manure appear about equally effective; but where phosphorus is not applied, manure has been decidedly more effective than residues, under the conditions of the experiment. It should be observed, however, in this connection, that the plowing under of clover is a very essential feature of the residues system, and that, as a matter of fact during the twelve years there were five clover failures, when soybeans were substituted. Perhaps with a more reliable biennial legume than red clover, the results would have been more favorable for this system.

By comparing Plots 2 and 3 with Plots 4 and 5, it is found that limestone has had a beneficial effect on practically all crops. What the financial profit

TABLE 3.—URBANA FIELD, DAVENPORT PLOTS: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

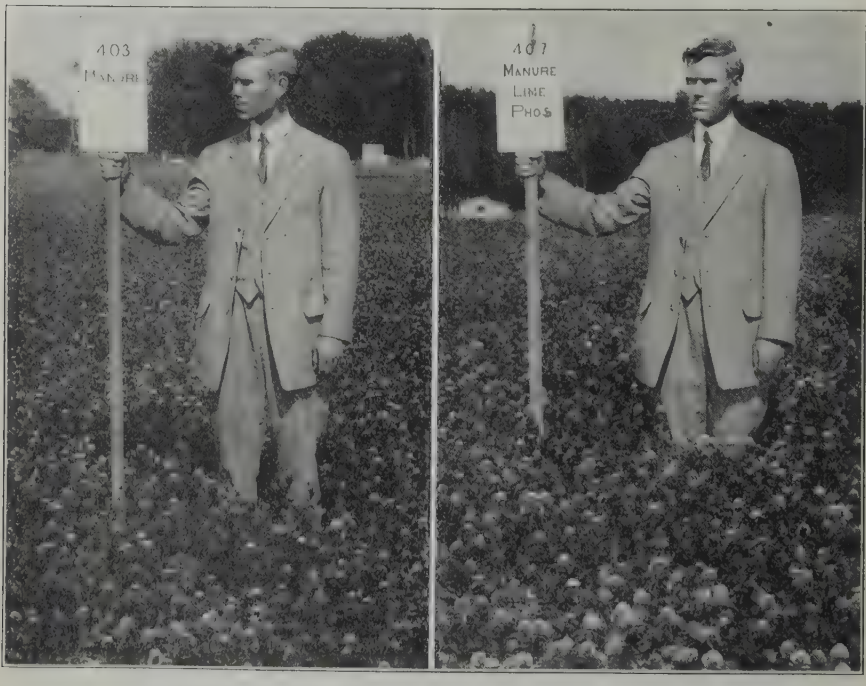
Average Annual Yields—Bushels or (tons) per acre
1911-1922

Serial plot No.	Soil treatment applied	Corn *12 crops*	Oats *12 crops*	Wheat *12 crops*	Legumes Clover *7 crops*	Legumes Soybeans *5 crops*	Alfalfa *12 crops*
1	0	55.6	52.5	25.9	(2.04)	(1.47)	(2.40)
2	R	56.3	53.7	28.4	1.42[1]	19.8	(2.54)
3	M	65.8	64.5	29.0	(2.21)	(1.62)	(2.51)
4	RL	64.4	56.0	31.5	1.64[1]	20.3	(2.79)
5	ML	69.9	64.4	33.8	(2.68)	(1.67)	(3.04)
6	RLP	71.3	69.0	42.1	1.90[1]	23.5	(3.85)
7	MLP	72.6	68.8	40.3	(3.26)	(1.97)	(3.92)
8	RLPK	70.8	71.4	39.9	1.51[1]	25.5	(4.02)
9	MLPK	70.0	71.4	39.3	(3.25)	(2.20)	(3.92)
10	Mx5LPx5	65.6	71.0	40.1	(2.84)	(2.22)	(3.92)

[1]In addition to the clover seed a crop of hay was taken from Plots 2, 4, 6, and 8 in the year 1918 and again in 1921, producing as an annual average for the seven years .46, .51, .59 and .59 tons respectively.

amounts to depends obviously upon the market value of the crops and the cost of the limestone.

Comparing Plots 4 and 5 with Plots 6 and 7, respectively, there is found in all cases an increase in crop yield as a result of adding phosphorus. The



Manure
Yield: 1.43 tons per acre

Manure, limestone, phosphorus
Yield: 2.90 tons per acre

FIG. 2.—CLOVER ON THE DAVENPORT PLOTS IN 1913

effect on wheat is especially pronounced. Where limestone and phosphorus are applied in addition to the crop residues, an increase of 16 bushels of wheat, over the yield of the untreated land, has been obtained as a twelve-year average.

The effect of adding potassium to the treatment is of much interest. Plots 8 and 9 are similar to Plots 6 and 7, respectively, except that potassium has been applied to the former. The small gains appearing in certain cases are counterbalanced by losses in others so that on the whole potassium treatment has not been profitable on these plots.

No benefit appears as the result of the extra-heavy applications of manure and phosphorus on Plot 10. In fact the corn yields are noticeably less here than on the plots receiving the normal applications of these materials.

The University South Farm

On the University South Farm, at Urbana, several series of plots devoted primarily to variety testing and other crop-production experiments are so laid out as to show the effects of certain soil treatments that have been applied. Several different systems of crop rotation are employed and the crops are so handled as to exemplify the two general systems of farming, grain and live-stock.

The summarized results presented in Table 4 represent three different systems of cropping. The first, designated as the Southwest rotation, is to be re-

Residues plowed under
Yield: 35.2 bushels per acre

Residues and rock phosphate
Yield: 50.1 bushels per acre

FIG. 3.—WHEAT ON THE UNIVERSITY SOUTH FARM IN 1911

TABLE 4.—URBANA FIELD, SOUTH FARM: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Southwest Rotation: Series 100, 200, 400[1]: Wheat, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn *9 crops*	Oats[3] *9 crops*	Wheat[3] *8 crops*	Clover[4] *3 crops*	Soybeans *7 crops*
RP	62.3	51.9	41.0	1.05	17.3[5]
R	51.9	46.5	26.9	1.38	16.2[5]
M	59.7	50.2	29.1	(2.28)	(1.25)
MP	64.3	55.4	43.1	(2.86)	(1.51)
RLP	60.5	57.2	41.8	.64	16.4[5]
R	49.7	49.6	25.8	.83	14.7[5]
M	55.5	54.1	27.8	(1.71)	(1.28)
MLP	64.1	59.6	43.9	(1.77)	(1.58)

North-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 1st year *9 crops*	Corn 2d year *9 crops*	Oats *9 crops*	Clover *5 crops*	Soybeans *4 crops*
RP	56.7	51.1	56.1	.54	16.9
R	51.7	45.2	52.0	.50	16.0
M	54.9	46.7	52.1	(2.29)	(1.60)
MP	56.5	53.4	56.9	(2.73)	(1.74)

South-Central Rotation: Series 500, 600, 700[1]: Corn, Corn. Corn, Soybeans

Soil treatment applied[6]	Corn 1st year *9 crops*	Corn 2d year *9 crops*	Corn 3d year *9 crops*		Soybeans *9 crops*
RP	51.9	44.0	41.3		20.0
R	45.5	39.9	35.2		19.2
M	50.1	42.1	33.5		(1.59)
MP	54.5	46.7	42.0		(1.66)

[1]Results from Series 300 and 800 are omitted on account of variation in soil type.
[2]Soybeans when clover fails.
[3]Only seven crops with limestone.
[4]Only one crop with limestone.
[5]Average of five crops.
[6]All phosphorus plots received ½ ton per acre of limestone in 1903.

garded as a good rotation for general practice, on this type of soil, under Illinois conditions. This is a four-field rotation of wheat, corn, oats, and clover. The second, or North-Central rotation, consisting of corn, corn, oats, and clover, represents a system very commonly practiced; and the third or South-Central rotation, consisting of corn, corn, corn, and soybeans, must be considered as a poor rotation from the standpoint of maintaining the productiveness of the land.

On the whole, the "residues" have not returned as high yields as those produced by the manure treatment; but, as remarked above in the discussion of the Davenport plots, the residues system has probably been at a disadvantage thru frequent clover failures. On the North-Central rotation, where conditions seem to have been more favorable for clover, there is relatively little difference between the effect of manure and of residues.

Limestone, which has been used in the southwest rotation, appears to have produced no increase of consequence to any of the crops except oats. The com-

parison may be somewhat impaired, however, by a possible residual effect of the small application of limestone made in 1903 to all the phosphorus plots.

The results obtained from the use of phosphorus are of especial interest because this element has been applied on this field solely in the form of raw rock phosphate. The figures in almost every case show an increase in yield where the phosphate has been applied, and in most cases this increase is very pronounced. The wheat is especially responsive to phosphorus.

The records from this field furnish some interesting comparisons of corn yields produced under different systems of cropping. Table 5 gives a general summary of the corn yields only, in which the results from the residues and manure treatments are averaged together as "organic manures." The highest annual acre-yields are found where corn occurs but once in a rotation. Where corn is grown twice in succession, the annual acre-yields are less; and where corn occurs three times, there is a further reduction. Also, the first crop of corn within a rotation produces more than the second, and the second crop yields more than the third. These are useful facts for consideration in connection with problems of general farm management.

TABLE 5.—COMPARING PRODUCTION OF CORN IN THREE DIFFERENT ROTATION SYSTEMS
ACRE YIELDS FROM PLOTS ON THE UNIVERSITY SOUTH FARM

Twelve-Year Average (1908–1919)—Bushels per acre

Rotation	Wheat-corn-oats-legume[1]	Corn-corn-oats-legume[2]		Corn-corn-corn-legume[3]		
Treatment	Corn	1st Corn	2d Corn	1st Corn	2d Corn	3d Corn
Organic manures	55.8	53.3	46.0	47.8	41.0	34.3
Organic manures, phosphorus	63.2	56.6	52.3	53.2	45.3	41.6

[1]Clover 3 crops, and soybeans 7 crops.
[2]Clover 5 crops, and soybeans 5 crops.
[3]Soybeans 9 crops.

The Joliet and Minonk Fields

Data from two fields on Brown Silt Loam located in the vicinity of Grundy county are introduced here. One of these fields is located near Joliet in Will county and the other at Minonk in Woodford county.

In considering the results from these two fields it should be pointed out that they represent opposite phases of Brown Silt Loam. The Joliet field is on a rather light phase while the Minonk field lies on a very heavy phase, approaching, in fact, Black Clay Loam in character. Moreover, the crop yields on the untreated land (Plots 1, 5, and 10) indicate that the Minonk field is on a considerably higher plane of natural productiveness than the Joliet field, which fact may account to a large extent for some of the discrepancies between the two fields in response to soil treatment. Probably most of the Brown Silt Loam as it exists in Grundy county lies somewhere between these two extremes with a relatively small proportion characteristic of the Joliet field. The lay-out of plots and the crop rotations on the two fields are alike. The summarized results of the three grain crops, corn, oats, and wheat, are given in Table 6, the yields for the legume crops being for the present purpose disregarded.

TABLE 6.—JOLIET and MINONK FIELDS: BROWN SILT LOAM, PRAIRIE; JOLIET, LATE WISCONSIN GLACIATION; MINONK, EARLY WISCONSIN GLACIATION

Average Annual Grain Yields—Bushels per acre

Soil treatment applied	Joliet Field (1915-1922)			Minonk Field (1912-1922)		
	Corn *10 crops*	Oats *7 crops*	Wheat *5 crops*	Corn *11 crops*	Oats *10 crops*	Wheat *8 crops*
0	28.1	61.1	25.4	51.4	59.9	34.1
M	36.3	66.8	30.3	60.2	59.8	36.9
ML	40.2	68.0	35.2	61.7	60.3	34.4
MLP	42.9	72.8	41.9	62.5	59.3	36.1
0	29.2	62.0	25.1	51.7	56.3	34.2
R	33.5	62.4	27.9	59.3	60.9	35.4
RL	37.4	63.2	28.9	62.1	61.0	32.6
RLP	41.7	67.8	38.7	61.4	63.2	34.3
RLPK	46.4	70.6	41.1	60.2	63.1	33.2
0	31.9	62.9	26.5	48.0	57.3	28.2
Increases—Bushels per acre						
M over 0	8.2	5.7	4.9	8.8	−0.1	2.8
ML over M	3.9	1.2	4.9	1.5	0.5	−2.2
MLP over ML	2.7	4.8	6.7	0.8	−1.0	1.7
R over 0	4.3	0.4	2.8	7.6	4.6	1.2
RL over R	3.9	0.8	1.0	2.8	0.1	−2.8
RLP over RL	4.3	4.6	9.8	−0.7	2.2	1.7
RLPK over RLP	4.7	2.8	2.4	−1.2	−0.1	−1.1

In looking over the results presented in Table 6, one of the first points of interest is the effect of farm manure. On both of these fields manure has produced a decided increase in yield of corn, and with the exception of the oats at Minonk, there has been a beneficial effect on all crops. This suggests the importance of carefully saving and regularly applying all available animal manure.

Residues, alone, have likewise given a substantial increase in corn, altho the response by the other crops is not so marked.

Limestone has given variable results. On the Joliet field all crops have shown some benefit from the use of limestone. On the other hand, the increases due to limestone on the Minonk field are not significant, some of the effects even appearing as negative. The response to limestone on these two fields is characteristic for the Brown Silt Loam of this region. Some of the land is in need of limestone and some of it is not. The limestone requirement, therefore, cannot be covered by a general prescription; rather, it is a matter to be determined for each individual farm or even for each individual field.

Rock phosphate has given very favorable returns as measured by increases in crop yields on the Joliet field. On the Minonk field, however, the opposite is true. The small differences appearing as the effect of the treatment are probably not significant, being within the range of the experimental error due to the natural plot variation. This variation in response to rock phosphate on Brown Silt Loam is likewise characteristic. On some experiment fields very pronounced and consistent gains have attended the use of this material. On other fields, however, where it has been applied in the same amounts and in similar manner, it has not produced sufficient increase to cover the cost. It remains for further investigation to explain this discrepancy.

The potassium fertilizer on the Joliet field has apparently produced a profitable gain, but on the Minonk field all of the "increases" are negative. The

favorable results for potassium at Joliet are unusual for this soil type. There is usually little or no response in the grain crops to potassium treatment on Brown Silt Loam.

YELLOW-GRAY SILT LOAM

Only one soil experiment field has been conducted on Yellow-Gray Silt Loam in northern Illinois altho there are several fields on this soil type in the southern part of the state. The Antioch field is located on the late Wisconsin glaciation, in Lake county, close to the Wisconsin border. The field was started in 1902, with but a single series of ten plots, under a rotation of corn, corn, oats, and wheat; but beginning with 1911 the rotation has been wheat, corn, oats, and

Lime applied and residues plowed under

Lime and phosphorus applied

FIG. 4.—CLOVER IN 1913 ON ANTIOCH FIELD

clover. It was started in order to learn as quickly as possible what effect would be produced by the addition to this type of soil of nitrogen, phosphorus, and potassium, used singly and in combination. These elements were all applied in commercial form until 1911, after which the use of commercial nitrogen was discontinued and crop residues were substituted in its place. Nitrogen was supplied in the earlier years in 800 pounds of dried blood per acre. Phosphorus is applied in 200 pounds of steamed bone meal, and potassium in 100 pounds of potassium sulfate. At the beginning, 470 pounds of slaked lime was applied; but since 1912 limestone has been applied at the rate of 1,000 pounds per acre per year.

Table 7 presents, in summarized form, the results with the grain crops from the Antioch field. Because of an abnormality in Plot 1, the results from this plot

TABLE 7.—ANTIOCH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LATE WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 8 crops	Oats 5 crops	Wheat 5 crops
1	0	23.9	32.3	14.7
2	L	21.3	26.8	13.3
3	LR	21.3	29.9	18.9
4	LP	30.7	43.6	35.0
5	LK	23.7	27.8	17.8
6	LRP	33.8	43.3	32.6
7	LRK	24.3	26.9	19.1
8	LPK	25.1	38.2	30.3
9	LRPK	38.3	42.6	28.1
10	RPK	38.4	44.7	31.0

are not considered. The data show that phosphorus is the one element standing out prominently as producing consistently beneficial results. Potassium applied in addition to phosphorus has, on the whole, not produced profitable results. Also, the results are unfavorable for the application of limestone. Limestone, however, is abundant in the subsoil of this type in the region of this field.

DUNE SAND

In 1913 the University came into possession of a tract of Dune Sand, Terrace, in Henderson county, near the Mississippi river, upon which an experiment field was laid out to determine the needs of these sand soils. This field is divided into six series of plots. Corn, soybeans, wheat, sweet clover, and rye, with a catch crop of sweet clover seeded in the rye on the residues plots, are grown in rotation on five series, while the sixth series is devoted to alfalfa. When sweet clover seeded in the wheat fails, cowpeas are substituted.

No catch of alfalfa or of sweet clover was obtained till the alfalfa drill was used in seeding. With this implement the seed is covered about one-half inch deep.

Table 8 indicates the kinds of treatment applied, the amounts of the materials used being in accord with the standard practice, as explained on page 53.

The data make apparent the remarkably beneficial action of limestone on this sand soil. Where limestone has been used in conjunction with crop residues, the yield of corn has been doubled. The limestone has also produced good crops of rye and fair crops of sweet clover and alfalfa.

This land appears to be quite indifferent to treatment with rock phosphate. The analyses show, however, that the stock of phosphorus in this type of soil is not large, and it may develop as time goes on and the supply diminishes along with the production of good-sized crops, that the application of this element will become profitable. It is also quite possible that a more available form of phosphate could be used to advantage on this very sandy soil.

Altho the results show an increase of 3.5 bushels of corn from the use of potassium salts, with ordinary prices this would not be a profitable treatment.

Manure
Yield: Nothing

Manure and limestone
Yield: 4.43 tons per acre

FIG. 5.—ALFALFA ON OQUAWKA FIELD IN 1918

The slight increase appearing in the other crops can scarcely be considered significant.

Experience thus far shows rye to be better adapted to this land than wheat, and both alfalfa and sweet clover thrive better than soybeans. With these two

TABLE 8.—OQUAWKA FIELD: DUNE SAND, TERRACE
Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn	Soybeans	Wheat	Sweet Clover 6 crops[1]		Rye	Alfalfa
		8 crops	*7 crops*	*8 crops*	*4 hay crops*	*2 seed crops*	*6 crops*	*5 crops*
1	0	17.8	(.88)	6.8	(.00)	.00	11.6	(.16)
2	M	22.1	(1.02)	9.4	(.00)	.00	12.7	(.26)
3	ML	28.3	(1.33)	12.7	(1.20)	.86	21.1	(1.76)
4	MLP	26.9	(1.28)	13.0	(1.26)	.75	19.9	(1.97)
					2 hay crops	*4 seed crops*		
5	0	17.4	5.5	9.0	(.00)	.00	12.0	(.08)
6	R	19.3	5.5	9.7	(.00)	.00	13.0	(.07)
7	RL	34.8	8.4	11.9	(1.47)	1.51	23.5	(1.78)
8	RLP	34.1	8.8	12.8	(1.39)	1.40	24.3	(1.69)
9	RLPK	37.6	8.5	11.7	(1.53)	1.71	24.6	(1.83)
10	0	14.9	(.61)	7.5	(.00)	.00	11.2	(.04)

[1]In 1918 sweet clover was killed by being cut for hay. Soybeans were seeded on these plots and the following yields obtained: .86, 1.10, 1.93, and 2.00 tons of hay per acre on Plots 1 to 4; 11.1, 9.9, 14.6, 15.8, and 16.6 bushels of seed per acre on Plots 5 to 9; and .62 ton of hay per acre on Plot 10.

legume crops thriving so well under this simple treatment, we have promise of great possibilities for the profitable culture of this land, which hitherto has been considered as practically worthless.

Deep Peat

The results secured on the Manito experiment field which was located on Deep Peat and which was in operation during the years 1902 to 1905, inclusive, are presented in Table 9.

There were ten plots receiving the treatments indicated in the table. Where potassium was applied, the yield was from three to four times as large as where nothing was applied. Where approximately equal money values of kainit and potassium chlorid were applied, slightly greater yields were obtained with the potassium chlorid, which, however, supplied about one-third more potassium than the kainit. On the other hand, either material furnished more potassium than was required by the crops produced.

The use of 700 pounds of sodium chlorid (common salt) produced no appreciable increase over the best untreated plots, indicating that where potassium is itself actually deficient, salts of other elements cannot take its place.

Applications of 2 tons per acre of ground limestone produced no increase in the corn crops, either when applied alone or in combination with kainit, either the first year or the second.

Reducing the application of kainit from 600 to 300 pounds for each two-year period reduced the total yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainit (Plot 9) furnished 60 pounds of potassium for the four years, an amount sufficient for 84 bushels of corn (grain and stalks). It is interesting to note that this is practically the difference between the yield of Plot 9 (125.9 bushels) and the yield obtained from Plot 2 (42.9 bushels), the poorest untreated plot.

TABLE 9.—MANITO FIELD: DEEP PEAT

Corn Yields—Bushels per acre

Plot No.	Soil treatment for 1902	Corn 1902	Corn 1903	Soil treatment for 1904	Corn 1904	Corn 1905
1	None	10.9	8.1	None	17.0	12.0
2	None	10.4	10.4	Limestone, 4000 lbs.	12.0	10.1
3	Kainit, 600 lbs.	30.4	32.4	Limestone, 4000 lbs. Kainit, 1200 lbs.	49.6	47.3
4	Kainit, 600 lbs. Acidulated bone, 350 lb.	30.3	33.3	Kainit, 1200 lbs. Steamed bone, 395 lbs.	53.5	47.6
5	Potassium chlorid, 200 lbs.	31.2	33.9	Potassium chlorid, 400 lbs.	48.5	52.7
6	Sodium chlorid, 700 lbs.	11.1	13.1	None	24.0	22.1
7	Sodium chlorid, 700 lbs.	13.3	14.5	Kainit, 1200 lbs.	44.5	47.3
8	Kainit, 600 lbs.	36.8	37.7	Kainit, 600 lbs.	44.0	46.0
9	Kainit, 300 lbs.	26.4	25.1	Kainit, 300 lbs.	41.5	32.9
10	None	[1]	14.9	None	26.0	13.6

[1]No yield was taken in 1902 because of a misunderstanding.

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 27

HANCOCK COUNTY SOILS

By R. S. SMITH, E. E. DE TURK, F. C. BAUER
AND L. H. SMITH

URBANA, ILLINOIS, MAY, 1924

The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or land owner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and land owner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in the form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due the late Professor J. G. Mosier, under whose direction the soil survey of Hancock county was conducted.

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HANCOCK COUNTY SOILS

APPENDIX

SUPPLEMENT

HANCOCK COUNTY SOILS

By R. S. SMITH, E. E. DeTURK, F. C. BAUER, and L. H. SMITH[1]

LOCATION AND CLIMATE OF HANCOCK COUNTY

Hancock county is located in the extreme western part of the state just orth of an east-west line running thru the center of the state. It is a medium-ized county containing 765 square miles.

The climate of Hancock county is apparently modified slightly by the lississippi river. The greatest range in temperature in any one year from 896 to 1923 was 129 degrees in 1914. The highest temperature recorded during his period was 108° in 1901; the lowest was –30° in 1905. The average date f the last killing frost in the spring is April 26 and the earliest in the fall is)ctober 8. The average length of the growing season is 168 days. Since 1896 he shortest growing season was 131 days in 1901 and the longest was 190 days n 1914.

The average annual rainfall for the county from 1896 to 1923 was 36.39 inches. The rainfall is well distributed, as is shown by the following figures which give the average rainfall by months for this period: January, 2.41 inches; February, 1.65; March, 2.89; April, 3.16; May, 4.82; June, 4.66; July, 3.80; August, 3.51; September, 4.47; October, 2.03; November, 1.80; December, 1.38.

AGRICULTURAL PRODUCTION

General farming, with live stock an important feature of the farming business, prevails in Hancock county. Owing to rough topography, about 20 percent of the area of the county is better adapted to permanent pasture than to the production of the ordinary farm crops, and much of it is used for this purpose. In 1920, as shown by the Fourteenth Census of the United States, there were 3,463 farms with an average size of 133.5 acres each, 105.7 acres of which were improved. Of these farms, 37.5 percent were operated by tenants, which represents a slight decrease in tenantry during the last twenty years.

The principal crops are corn, oats, wheat, rye, and forage crops, including timothy, clover, mixed clover and timothy, silage crops, and corn cut for forage. The census reports the following acreage and yield for the more important crops for 1919.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn	102,612	4,065,339 bu.	39.6 bu.
Oats	50,362	1,865,165 bu.	37.0 bu.
Wheat	60,714	1,216,445 bu.	20.0 bu.
Rye	22,743	303,230 bu.	13.3 bu.
Timothy alone	9,036	11,049 tons	1.22 tons
Timothy and clover mixed	20,981	26,622 tons	1.27 tons
Clover alone	11,010	14,019 tons	1.27 tons
Silage crops	3,379	25,341 tons	7.50 tons
Corn cut for forage	6,144	13,176 tons	2.14 tons

[1]R. S. Smith, in charge of soil survey mapping; E. E. DeTurk, in charge of soil analysis; F. C. Bauer, in charge of experiment fields; L. H. Smith, in charge of publications.

The live-stock interests are important in Hancock county, as is shown by the following figures taken from the 1920 census.

Animals and animal products	*Number*	*Value*
Horses	20,318	$1,783,865
Mules	1,337	161,069
Beef cattle	33,170	1,942,851
Dairy cattle	13,153	880,166
Sheep	11,909	154,902
Swine	96,618	1,778,411
Chickens and other poultry	386,751	384,796
Eggs and chickens	———	1,093,222
Dairy products	———	561,938
Bees	2,622 (hives)	17,893
Honey and wax	37,071 (lbs.)	8,599

Fruit growing is of comparatively little importance in the county, excepting in the case of grapes. In 1919 there were harvested 2,148,662 pounds of grapes, which places this county far in the lead of any other county in the state in grape production. In view of the considerable area of land better adapted to orchards than to field crops, and the favorable climatic conditions of this region, more attention might well be given to the production of orchard fruits, especially of apples.

SOIL FORMATION

The most important period in the geological history of Illinois from the standpoint of soil formation was the Glacial period, during and immediately following which time the materials were deposited from which the soils of the state were later in large part formed. At that time snow and ice accumulated in the region of Labrador and to the west of Hudson Bay in such large amounts that the mass pushed outward from these centers, chiefly southward. In moving across the country from the north, the ice gathered up all sorts and sizes of material, including clay, silt, sand, gravel, boulders, and even large masses of rock. As the ice mass pushed along over its bed, an immense amount of rock powder was produced by the grinding or file-like action of the rock material imbedded in the ice. The front of the ice continued to advance until the rate of melting back just balanced the rate of forward movement. During the time when the front of the ice sheet was stationary, that is, when the rate of melting back equaled the rate of advance, the rock material which had been brought forward accumulated in a broad, usually undulating, ridge known as a terminal moraine. When the ice sheet melted more rapidly than the glacier advanced, the terminus of the glacier would recede and the material would be deposited somewhat irregularly over the area previously covered. Such a deposit made as the ice sheet receded is known as a ground moraine.

During the Glacial period at least six distinct ice advances occurred that were separated by long periods of time. They are described as follows, in the order of their occurrence:

(1) The Nebraskan, which did not touch Illinois; (2) the Kansan, which covered the western parts of Hancock and Adams counties; (3) the Illinoisan, which covered all of the state except the northwest county (Jo Daviess), the southern part of Calhoun county, and the seven southernmost counties; (4) the Iowan, which covered a part of northern Illinois, the exact area, however,


LEGEND
D PRAIRIE SOILS
wn silt loam
wn-gray silt loam on tight clay
ck silt loam on clay
ck clay loam
wn fine sandy loam
D TIMBER SOILS
low-gray silt loam
low silt loam
low-gray fine sandy loam
low fine sandy loam
ht gray silt loam
tight clay
BOTTOM LAND SOILS
own silt loam
ab clay
own sandy loam
xed loam
llow fine sandy loam
own silt loam on sand
ver sand
ab clay on sand
UAL
ck outcrop
nolsan moraines
per Illinoisan glaciation
ep loess
d bottom land
te bottom land
rrace
esidual
TERRACE SOILS
1520.5 Black clay loam on rock
1560.5 Brown sandy loam on rock
OLD BOTTOM LAND SOILS
1326 Deep brown silt loam
1354 Mixed loam
Scale
0 1/4 1/2 1 2 Miles
R. 7 W.
R. 8 W.
R. 9 W.
MISSISSIPPI RIVER
Niota
Pontoosuc
Nauvoo City
Powellton
Sonora
Hamilton
Elvaston
Mc Call
DAM
FERRY
ATCH. TOPS. SANTA
TOLEDO PEORIA
WABASH
Tyson Cr.
Robinsons Cr.
Chandler Cr.
Sugar Cr.
S. Branch
Larrys Cr.
Waggoner Cr.
Cheney Cr.

SOIL SURV

AP OF HANCOCK COUNTY

being difficult to determine because of the effect of the subsequent glaciations; (5) the early Wisconsin, which covered the northeastern part of the state as far west as Peoria and as far south as Shelbyville; (6) the late Wisconsin, which extended to the west line of McHenry county and south to the town of Milford in Iroquois county.

The material transported by the glaciers varied with the character of the rocks over which they passed. Granites, sandstones, limestones, shales, etc., were torn from their lodging places by the enormous denuding power of the ice sheet and ground up together. A pressure of forty pounds per square inch is exerted by a mass of ice one hundred feet thick, and these ice sheets were hundreds or possibly thousands of feet in thickness. Pre-glacial ridges and hills were rubbed down, valleys were filled with the debris, and the surface features were entirely changed. The mixture of materials deposited by the glaciers is known as boulder clay, till, glacial drift, or simply drift. The average depth of this deposit over the state of Illinois is estimated as 115 feet.

Previous to the ice invasion, this region generally was not well suited to agriculture because of its rough and hilly character, as is shown by borings which indicate many preglacial valleys that later were filled with drift. The general effect of the glaciers was to change the surface from hilly to gently undulating. Only a few streams have done much to change the topography, and these in only very limited areas.

THE GLACIATIONS OF HANCOCK COUNTY

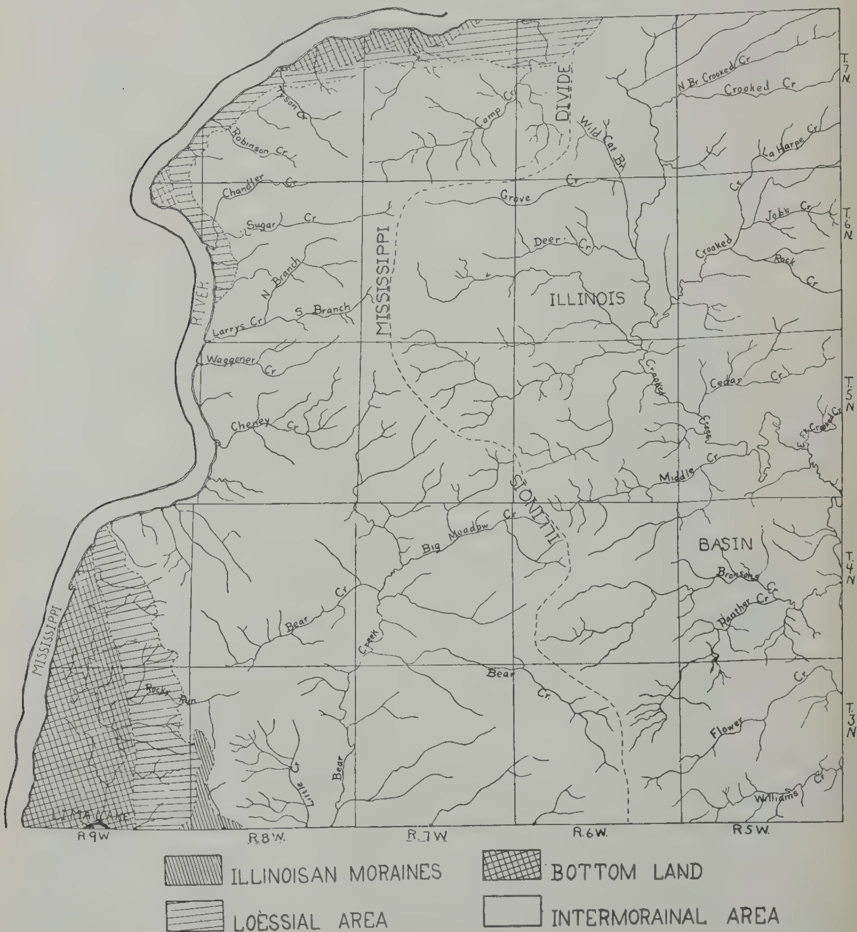
Hancock county was covered in part by the Kansan and entirely by the Illinoisan glacier. It received extensive deposits of glacial drift, yet very little of the present soil has been formed directly from it. Later deposits of rock flour, or loess, buried the drift, so that it is now exposed only in ravines and gullies where erosion has removed the blanket of wind-deposited loess. The extent of the Kansan ice sheet in this state is rather difficult to determine because the Illinoisan drift sheet has buried the Kansan drift to a depth of 20 to 200 feet or more. Before the Glacial period, the region of Hancock county was hilly, as is shown by the presence of drift-filled valleys that have been found in drilling wells. One of these old buried valleys near Carthage was filled to a depth of 214 feet, and there are many others fully as deep. All surface indications of many of these valleys have been completely obliterated.

The only moraine in Hancock county extends southward from Warsaw about two miles from the bluff of the Mississippi river. This ridge extends into Adams county at the south and apparently marks the western limit of the Illinoisan glacial lobe. The drift is mainly a compact material, averaging from 50 to 60 feet in depth, and is covered with a layer of wind-blown material, or loess, varying from 4 to 20 feet in depth. The deeper part of the loess is near the Mississippi bluff, and in places where the adjoining bottom land is widest. The drift is not usually uniform in composition, but contains strata of sand, gravel, and fine material. About four miles south of Hamilton, a peaty soil containing wood was struck at a depth of about 42 feet. This formation probably represents the soil formed on the Kansan drift and later buried by the Illinoisan drift sheet. It is called the Yarmouth soil.

PHYSIOGRAPHY AND DRAINAGE

The valley of the Mississippi river is from 150 to 200 feet below the upland. The altitudes of some places in Hancock county are as follows: Adrian, 705 feet; Augusta, 672; Basco, 650; Bentley, 671; Bowen, 693; Burnside, 665; Carthage, 678; Chile, 670; Colusa, 653; Dallas, 536; Denver, 680; Disco, 671; Durham, 685; Elvaston, 675; Ferris, 685; Hamilton, 515; LaCrosse, 645; LaHarpe, 691; McCall, 699; Nauvoo, 500; Niota, 520; Plymouth, 642; Pontoosuc, 534; Powellton, 683; Sonora, 510; Stillwell, 669; Sutter, 700; Tioga, 700; Warsaw, 490; Webster, 685; West Point, 667.

The highest part of the county is the morainal ridge extending in a north-south direction just west of Tioga. The highest point is in Section 6 of Walker township (Township 3 North, Range 8 West). This point is approximately 765 feet above sea level.



MAP SHOWING THE DRAINAGE BASINS OF HANCOCK COUNTY WITH MORAINAL, INTERMORAINAL, LOESSIAL, AND BOTTOM-LAND AREAS

LEGEND

UPLAND PRAIRIE SOILS

- 26, 226, 526 Brown silt loam
- 28, 528 Brown-gray silt loam on tight clay
- 525.1 Black silt loam on clay
- 520 Black clay loam
- 71, 87 Brown fine sandy loam

UPLAND TIMBER SOILS

- 34, 234, 534 Yellow-gray silt loam
- 35, 535 Yellow silt loam
- 874 Yellow-gray fine sandy loam
- 875 Yellow fine sandy loam
- 532 Light gray silt loam on tight clay

OLD BOTTOM LAND SOILS

- 1326 Deep brown silt loam
- 1354 Mixed loam

LATE BOTTOM LAND SOILS

- 1426 Brown silt loam
- 1415 Drab clay
- 60, 1460 Brown sandy loam
- 1454 Mixed loam
- Yellow fine sandy loam
- 1426.2 Brown silt loam on sand
- 1480 River sand
- 1415.3 Drab clay on sand

TERRACE SOILS

- 1520.5 Black clay loam on rock
- 1560.5 Brown sandy loam on rock

RESIDUAL

- 099 Rock outcrop

200 Illinoisan moraines
500 Upper Illinoisan glaciation
800 Deep loess
1300 Old bottom land
1400 Late bottom land
1500 Terrace
000 Residual

Scale
0 1/4 1/2 1 2 Miles

SOIL SURVEY MAP
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HANCOCK COUNTY
RAL EXPERIMENT STATION

The county is divided into two principal drainage areas, one of which drains into the Mississippi and the other into the tributaries of the Illinois. The area draining into the Mississippi is about 6 miles wide at the north and 22 miles wide at the south. From the north line of the county to the town of Warsaw, the Mississippi flows in a valley that is but very little wider than the river itself. South of Warsaw the valley widens out until at the south line of the county, the bottom land is about 4 miles wide. Bear creek is the principal stream in Hancock county flowing into the Mississippi river.

The northern half of the Mississippi drainage area has numerous short streams flowing in deep valleys. The upland is rather flat and part of the divide between the Mississippi and the Illinois river is very flat and rather poorly drained. This area is occupied by the soil types Black Clay Loam and Black Silt Loam On Clay. The area along Bear creek in the southern two townships thru which this stream runs is very badly eroded, a great deal of the area being unfit for cultivation. Its only use is for pasture or fruit. The divide between the Mississippi and the Illinois drainage systems in the southern part of the county passes thru Carthage and Bowen. South of Bowen there is an area of flat, poorly drained land that is occupied mainly by Black Silt Loam On Clay.

The eastern part of the county constitutes the other large drainage area. This area is drained by Crooked creek and its tributaries into the Illinois river. This region is badly cut up by numerous streams that flow from McDonough county westward. The bottom land of Crooked creek varies greatly in width. At three places it is contracted to a width but little more than that of the creek itself; it then expands so that it is a mile or more in width. A series of very interesting curves or crooks, that help to give Crooked creek its name, occur in the southeast corner of Hancock township (Township 5 North, Range 5 West).

SOIL MATERIALS AND SOIL TYPES

Altho Hancock county was covered, during the Glacial period, with a deposit of drift ranging from about 20 to over 200 feet deep, this drift forms the present surface only where erosion has been active. By far the largest part of the soil material has been transported and deposited upon the drift by wind, as explained above. This formation, which is called loess, varies from 4 to 25 feet in depth. This deposit seems to have been laid down, in part, at a time immediately following the Illinoisan glaciation, and in part later. This difference in time of deposition is indicated by a mature, well formed subsurface and subsoil over most of the county, indicating age, while in the north-central portion of the county, the subsurface and subsoil development has not progressed very far. This latter area is leached of its carbonate to a less depth than is the case in the former area, which fact also shows a difference in age.

Exclusive of bottom land, there are three general soil areas in Hancock county located as follows: (1) two areas of deep loess along the Mississippi bluff, one in the southwest part of the county about two miles wide extending south from Warsaw, and the other varying in width from one-half to two miles and extending north from Sonora; (2) the comparatively small area in the

TABLE 1.—SOIL TYPES OF HANCOCK COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (200, 500, 800)			
226 526	Brown Silt Loam	255.08	163,252	33.35
528	Brown-Gray Silt Loam On Tight Clay	57.20	36,608	7.48
525.1	Black Silt Loam On Clay	30.56	19,558	4.00
520	Black Clay Loam	1.76	1,126	.23
871	Brown Fine Sandy Loam	.76	486	.10
		345.36	221,029	45.16
	(b) Upland Timber Soils (200, 500, 800)			
234 534	Yellow-Gray Silt Loam	166.24	106,395	21.73
535	Yellow Silt Loam	146.08	93,492	19.10
874	Yellow-Gray Fine Sandy Loam	14.96	9,574	1.96
875	Yellow Fine Sandy Loam	16.08	10,291	2.10
532	Light Gray Silt Loam On Tight Clay	2.68	1,715	.35
		346.04	221,465	45.24
	(c) Terrace Soils (1500)			
1520.5	Black Clay Loam On Rock	.12	77	.02
1560.5	Brown Sandy Loam On Rock	.28	179	.04
		.40	256	.06
	(d) Old Bottom-Land Soils (1300)			
1325	Deep Brown Silt Loam	29.36	18,790	3.84
1354	Mixed Loam	9.28	5,939	1.21
		38.64	24,729	5.05
	(e) Late Bottom-Land Soils (1400)			
1426	Brown Silt Loam	10.88	6,963	1.42
1415	Drab Clay	7.76	4,966	1.01
1460	Brown Sandy Loam	7.88	5,043	1.03
1454	Mixed Loam	2.36	1,510	.31
1475	Yellow Fine Sandy Loam	3.84	2,458	.50
1426.2	Brown Silt Loam On Sand	.40	256	.05
1480	River Sand	.32	205	.04
1415.3	Drab Clay On Sand	.60	384	.08
		34.04	21,785	4.44
	(f) Residual (000)			
099	Rock Outcrop	.16	102	.02
	(g) Miscellaneous			
	Water	.24	154	.03
	Total	764.88	489,523	100.00

north-central part of the county made up of soils having very pervious subsoils; and (3) the balance of the county made up of soils, the subsoils of which are of a more clayey nature, less pervious to water and air. Much of the Brown-Gray Silt Loam On Tight Clay and the Black Silt Loam On Clay are found in this third area. Even in the case of the timber types, the subsoils are less pervious than they are usually found to be in the latitude of Hancock county.

The various types of soils of the county as determined by the suvery are classified into six groups as follows:

(a) *Upland Prairie Soils,* including the upland soils that have not been covered with forests and in which the luxuriant growth of prairie grasses has produced relatively large amounts of organic matter.

(b) *Upland Timber Soils,* including nearly all the upland areas that are now, or were formerly, covered with forests.

(c) *Terrace Soils,* including bench lands or second bottom lands formed by deposits from overloaded streams.

(d) *Old Bottom-Land Soils,* including the low-lying land along streams other than the Mississippi river and formed of older materials than those of the late bottom lands.

(e) *Late Bottom-Land Soils,* including the bottom lands of the Mississippi river and representing a newer formation than the old bottom lands.

(f) *Residual,* including rock outcrop.

Table 1 gives a list of the soil types found in Hancock county, classified according to the groups described above. It also shows the area of each type in square miles and in acres and its percentage of the total area of the county. For example, it will be observed that 45.16 percent of the area consists of upland prairie soil, 45.24 percent of upland timber soil, .06 percent of terrace soil, 5.05 percent of old bottom-land soils, and 4.44 percent of late bottom-land soils.

The accompanying maps show the location and boundary lines of every type of soil in the county, even down to areas of a few acres in extent.

For explanations concerning the classification of soils and the interpretation of the maps and tables, the reader is referred to the first part of the Appendix to this report.

INVOICE OF THE ELEMENTS OF PLANT FOOD IN HANCOCK COUNTY SOILS

In order to obtain a knowledge of its chemical composition, each soil type is sampled in the manner described below and subjected to chemical analysis for its important plant-food elements. For this purpose, samples are taken usually in sets of three to represent different strata in the top 40 inches of soil; namely, an upper stratum (0 to 6⅔ inches), a middle stratum (6⅔ to 20 inches), and a lower stratum (20 to 40 inches). These sampling strata correspond approximately in the common kinds of soil to 2,000,000 pounds per acre of dry soil in the upper stratum, and to two times and three times this quantity in the middle and lower strata respectively. This, of course, is a purely arbitrary division of the soil section, very useful in arriving at a knowledge of the quantity and the distribution of the elements of plant food in the soil, but it should be borne in mind that these strata seldom coincide with the natural strata as they actually exist in the soil, and which are referred to in describing the soil types as surface, subsurface, and subsoil. By this system of sampling, we have represented separately three zones for plant feeding. The upper, or surface layer includes at least as much soil as is ordi-

narily turned with the plow, and this is the part with which the farm manure, limestone, phosphate, or other fertilizing material is incorporated.

The chemical analysis of a soil, obtained by the methods here employed gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed, but it should be understood that the rate of liberation from their insoluble forms is governed by many factors.

For convenience in making application of the chemical analyses the results as presented here have been translated from the percentage basis and are given in the accompanying tables in terms of pounds per acre. In this, the assumption is made that for ordinary types a stratum of dry soil of the area of an acre and 6⅔ inches thick weighs 2,000,000 pounds. It is understood, of course, that this value is only an approximation, but it is believed that, with this understanding, it will suffice for the purposes intended. It is, of course, a simple matter to convert these figures back to the percentage basis in case one desires for any purpose to consider the information in that form.

THE UPPER SAMPLING STRATUM

In Table 2 are reported the amount of organic carbon (which serves as a measure of the total organic matter), and the total quantities of nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium in two million pounds of the surface soil (the plowed soil of an acre about 6⅔ inches deep) of each type in Hancock county.

Because of the extreme variations frequently found within a given soil type with respect to the presence of limestone and acidity in the different strata, no attempt is made to include in the tabulated results figures purporting to represent their averages in the respective types. In examining each soil type, however, numerous qualitative tests are made which furnish general information regarding the soil reaction, and in the discussions of the individual soil types which follow, recommendations based upon these tests are given concerning the lime requirement of the respective types. Such recommendations cannot be made specific in all cases because local variations exist, and because the lime requirement may change from time to time, especially under cropping. Therefore, it is often desirable to determine the lime requirement for a given field, as explained in the Appendix, page 32.

In connection with Table 2, it is of interest to note the variation among the different soil types with respect to their content of the various plant-food elements. It will be seen from the analyses that in all the soil types the amount of nitrogen is a little less than $\frac{1}{10}$ that of total organic carbon, which is used as an index of the organic-matter content of the soil. This constant proportion is an indication of the close association of nitrogen with the organic matter of the soil. This consistent relationship is not to be observed between any of the other elements. The organic matter with its nitrogen varies widely in amount in the different soils of the county. The highest content of organic carbon, 72,200 pounds per acre, was found in the Black Clay Loam On Rock in the Mississippi terrace, and this soil also contained the highest amount of nitrogen, 5,820 pounds per acre. The sand soil in the Mississippi bottom, on the other hand, contained the smallest amounts of both organic carbon and nitrogen, the respective amounts being 11,200 and 640 pounds per acre. It is of interest

TABLE 2.—PLANT-FOOD ELEMENTS IN THE SOILS OF HANCOCK COUNTY, ILLINOIS
UPPER SAMPLING STRATUM: ABOUT 0 TO 6⅔ INCHES
Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (200, 500, 800)							
226, 526	Brown Silt Loam	49 650	3 940	1 010	630	31 820	7 630	10 730
528	Brown-Gray Silt Loam On Tight Clay	43 470	3 550	870	680	31 190	6 380	9 330
525.1	Black Silt Loam On Clay	69 290	5 380	1 380	690	28 930	11 360	16 970
520	Black Clay Loam	46 940	5 340	1 760	1 180	29 960	13 720	18 060
871	Brown Fine Sandy Loam	49 660	3 960	1 220	720	32 320	8 720	12 880
	(b) Upland Timber Soils (200, 500, 800)							
234, 534	Yellow-Gray Silt Loam	28 500	2 450	800	490	32 850	6 140	8 070
535	Yellow Silt Loam	25 920	2 320	770	360	33 500	6 230	7 670
874	Yellow-Gray Fine Sandy Loam	28 680	2 550	1 010	510	34 310	6 180	10 280
875	Yellow Fine Sandy Loam	19 040	1 880	620	420	34 100	5 940	10 600
532	Light Gray Silt Loam On Tight Clay	21 460	2 040	660	440	32 640	5 200	10 220
	(c) Terrace Soils (1500)							
1520.5	Black Clay Loam On Rock	72 200	5 820	1 480	1 180	21 400	8 300	17 320
1560.5	Brown Sandy Loam On Rock	47 940	4 180	1 300	800	23 740	6 000	10 620
	(d) Old Swamp and Bottom-Land Soils (1300)							
1326	Deep Brown Silt Loam	31 620	2 500	960	340	32 740	8 000	11 660
1354	Mixed Loam[1]							
	(e) Late Swamp and Bottom-Land Soils (1400)							
1426	Brown Silt Loam	45 840	3 840	2 180	660	31 100	10 500	14 840
1415	Drab Clay	42 200	3 380	1 760	740	35 100	13 980	15 320
1460	Brown Sandy Loam	32 260	2 980	1 460	580	31 080	8 820	14 620
1475	Yellow Fine Sandy Loam	29 480	2 560	1 320	480	29 360	7 440	17 740
1426.2	Brown Silt Loam On Sand	42 160	3 720	1 720	680	32 900	11 400	15 120
1480	River Sand	11 200	640	700	280	19 700	2 720	8 180
1415.3	Drab Clay On Sand	51 740	4 840	1 800	960	33 680	14 420	16 360

LIMESTONE AND SOIL ACIDITY.—In connection with these tabulated data it should be explained that the figures for limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in the form of general numerical averages reliable information concerning the limestone requirement for a given soil type. A general statement, however, will be found concerning the lime requirement of the respective soil types in connection with the discussions which follow.

[1]On account of the heterogeneous character of Mixed Loam, chemical analyses are not included for this type.

further to note the relatively larger amounts of organic carbon and nitrogen in the upland prairie soils as compared with the upland timber soils. The five prairie soil types in the county contain, as an average, 50,800 pounds per acre of organic carbon and 4,400 pounds of nitrogen. The five timber soil types average about half as much, or 24,600 pounds and 2,200 pounds of the two elements respectively. The relative deficiency of the timber soils in the total amounts of these important elements serves to emphasize the necessity of giving

TABLE 3.—PLANT-FOOD ELEMENTS IN THE SOILS OF HANCOCK COUNTY, ILLINOIS
MIDDLE SAMPLING STRATUM: ABOUT 6⅔ TO 20 INCHES
Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (200, 500, 800)							
226, 526	Brown Silt Loam	64 670	5 150	1 630	900	64 540	18 700	20 150
528	Brown-Gray Silt Loam On Tight Clay	47 020	3 860	1 320	670	64 120	16 490	17 540
525.1	Black Silt Loam On Clay	82 160	6 440	2 150	1 280	58 120	25 290	36 490
520	Black Clay Loam	85 440	7 040	3 280	880	58 040	29 640	43 240
871	Brown Fine Sandy Loam	63 720	5 440	1 960	1 160	63 720	20 720	24 960
	(b) Upland Timber Soils (200, 500, 800)							
234, 534	Yellow-Gray Silt Loam	21 790	2 210	1 440	690	66 880	19 700	8 070
535	Yellow Silt Loam	18 270	2 150	1 440	760	69 110	19 240	14 400
874	Yellow-Gray Fine Sandy Loam	23 920	2 300	1 540	840	71 360	16 240	18 340
875	Yellow Fine Sandy Loam	12 240	1 640	1 640	640	68 000	22 720	22 760
532	Light Gray Silt Loam On Tight Clay	22 880	2 080	1 200	480	65 400	15 600	20 320
	(c) Terrace Soils (1500)							
1520.5	Black Clay Loam On Rock	90 560	6 840	2 080	1 880	46 040	18 760	35 280
1560.5	Brown Sandy Loam On Rock	77 160	6 680	2 360	1 560	47 720	11 880	22 240
	(d) Old Swamp and Bottom-Land Soils (1300)							
1326	Deep Brown Silt Loam	62 320	5 080	2 200	600	66 600	16 520	21 760
1354	Mixed Loam[1]							
	(e) Late Swamp and Bottom-Land Soils (1400)							
1426	Brown Silt Loam	52 520	4 440	2 640	1 240	60 160	17 680	28 680
1415	Drab Clay	63 240	4 600	3 240	1 480	69 680	29 480	31 640
1460	Brown Sandy Loam	38 200	3 560	2 240	760	59 560	15 600	26 520
1475	Yellow Fine Sandy Loam	46 800	4 080	2 160	880	57 200	16 240	38 040
1426.2	Brown Silt Loam On Sand	24 840	2 080	2 040	640	53 840	15 240	23 160
1480	River Sand	11 920	760	1 240	440	42 640	6 400	19 000
1415.3	Drab Clay On Sand	53 280	5 080	2 120	1 280	60 160	21 000	31 280

LIMESTONE AND SOIL ACIDITY.—See note in Table 2

[1]On account of the heterogeneous character of Mixed Loam, chemical analyses are not included for this type.

particular attention to the return of organic materials to soils of this group in planning crop rotations. Other elements are not so closely associated with each other as are nitrogen and organic matter, altho there is a rather high correlation between the sulfur content and the amount of organic matter and nitrogen. Otherwise the elements vary independently and within a fairly wide range as a rule. Thus the phosphorus content varies from 620 pounds per acre in Yellow Fine Sandy Loam to 2,180 pounds in Brown Silt Loam, Bottom. Magnesium ranges from 2,720 pounds in River Sand to a maximum of 14,420 pounds in Drab Clay On Sand, while total calcium ranges from 7,670 to 18,060 pounds per acre. The potassium content of all the soils is fairly constant at about

TABLE 4.—PLANT-FOOD ELEMENTS IN THE SOILS OF HANCOCK COUNTY, ILLINOIS
LOWER SAMPLING STRATUM: ABOUT 20 TO 40 INCHES
Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phos-phorus	Total sulfur	Total potas-sium	Total magne-sium	Total calcium
	(a) Upland Prairie Soils (200, 500, 800)							
226, 526	Brown Silt Loam........	37 530	3 560	2 360	980	93 980	42 450	35 040
528	Brown-Gray Silt Loam On Tight Clay............	36 870	3 600	2 370	770	90 160	43 340	32 230
525.1	Black Silt Loam On Clay.	58 580	4 260	2 760	840	89 680	40 880	46 260
520	Black Clay Loam.......	52 740	4 320	3 480	660	91 140	40 680	89 580
871	Brown Fine Sandy Loam.	27 420	3 120	2 760	900	98 280	43 980	43 080
	(b) Upland Timber Soils (200, 500, 800)							
234, 534	Yellow-Gray Silt Loam...	20 190	2 480	2 990	850	97 430	43 600	27 700
535	Yellow Silt Loam.......	16 320	2 180	3 140	880	96 640	39 020	24 820
874	Yellow-Gray Fine Sandy Loam.................	23 790	2 280	3 270	960	102 810	39 360	30 270
875	Yellow Fine Sandy Loam.	10 620	1 740	3 720	480	102 960	40 020	40 080
532	Light Gray Silt Loam On Tight Clay............	18 540	2 280	3 120	540	91 500	41 520	34 380
	(c) Terrace Soils (1500)							
1520.5	Black Clay Loam On Rock[1]................							
1560.5	Brown Sandy Loam On Rock[1]................							
	(d) Old Swamp and Bottom-Land Soils (1300)							
1326	Deep Brown Silt Loam...	47 400	4 500	3 360	600	98 820	23 880	26 460
1354	Mixed Loam[2]..........							
	(e) Late Swamp and Bottom-Land Soils (1400)							
1426	Brown Silt Loam........	43 380	3 600	3 240	1 080	89 940	25 260	41 580
1415	Drab Clay.............	70 200	5 400	4 500	1 860	102 720	44 880	48 180
1460	Brown Sandy Loam.....	17 040	900	2 160	600	71 400	15 120	32 580
1475	Yellow Fine Sandy Loam.	83 340	7 260	3 720	1 380	91 860	23 100	46 680
1426.2	Brown Silt Loam On Sand	11 820	720	2 160	840	63 120	11 760	29 520
1480	River Sand.............	19 440	1 080	1 920	660	67 620	11 640	29 280
1415.3	Drab Clay On Sand.....	22 920	1 200	2 940	180	67 620	13 860	29 520

LIMESTONE AND SOIL ACIDITY.—See note in Table 2

[1]No samples were taken because this stratum is rock. [2]On account of the heterogeneous character of Mixed Loam, chemical analyses are not included for this type.

30,000 pounds per acre, with only three significant variations, namely, the two soils on the terrace and the River Sand. The amount of total potassium present is far in excess of maximum crop requirements. The only important soil type which is characteristically deficient in total potassium is Peat, a type not represented in Hancock county.

THE MIDDLE AND LOWER SAMPLING STRATA

In Tables 3 and 4 are recorded in a similar manner the amounts of the plant-food elements in the middle and lower sampling strata. It is frequently of interest to know the total supply of plant-food elements accessible to the

growing crops. While it is impracticable to obtain this information exactly, especially for the deeper-rooted crops, it seems probable that the bulk of the feeding range of the roots of most of our common field crops is included in the upper 40 inches of soil. By adding together for a given soil type the corresponding figures in Tables 2, 3, and 4, the total amounts of the respective plant-food elements to a depth of 40 inches may be ascertained.

A wide range of variation with respect to composition is found to occur in the sub-layers as well as in the top layer of the various soil types. The tables reveal further that there is not only this wide diversity among the different soils with respect to a given plant-food element, but that there is also a great variation with respect to the relative abundance of the various elements within a given soil type as measured by crop requirements. For example, in the most extensive upland prairie type in the county, Brown Silt Loam, we find that the total quantity of nitrogen in an acre to a depth of 40 inches amounts to 12,650 pounds. This is about the amount of nitrogen contained in 12,600 bushels of corn. The amount of phosphorus, 5,000 pounds, contained in the same soil is equivalent to that contained in 22,000 bushels of corn, while in the same quantity of this soil there is present 190,340 pounds of potassium, the equivalent of that contained in 1 million bushels of corn. The most extensive upland timber soil in the county, Yellow-Gray Silt Loam, contains in the entire 40-inch stratum, approximately 7,000 pounds per acre of nitrogen, an amount equal to that in 7,000 bushels of corn, while the amounts of phosphorus and potassium in the same quantity of this soil are essentially the same as in the Brown Silt Loam.

These statements are not intended to imply that it is possible to predict how long it might be before a certain soil would become exhausted under a given system of cropping. Neither do the figures necessarily indicate the immediate procedure to be followed in the improvement of a soil, for other factors enter into consideration aside from the mere amount of plant-food elements present in the soil. Much depends upon the nature of the crops to be grown as to their utilization of plant-food materials, and much depends upon the condition of the plant-food substances themselves as to their availability. Finally in planning the detailed procedure for the improvement of a soil, there enter for consideration all the economic factors involved in any fertilizer treatment. Such figures do, however, furnish an inventory of the total stocks of the plant-food elements that can possibly be drawn upon and in this way these chemical data contribute fundamental information for the planning, in a broad way, of systems of soil management for conserving and improving the fertility of the land.

DESCRIPTION OF INDIVIDUAL SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of Hancock county occupy 345.36 square miles, or somewhat less than half of the area of the county. They vary from black to light brown or grayish brown in color in the surface, owing to the variation in amount and condition of the organic matter. The prairie soils of the county, with the exception of those found in the north-central portion, chiefly in Durham township (Township 7 North, Range 6 West), have a tendency towards compactness in the subsoil. This character is not sufficiently developed to interfere

with water and root penetration excepting in the areas mapped as Brown-Gray Silt Loam On Tight Clay. The plastic and impervious nature of the subsoil of this type makes successful underdrainage difficult, or even impossible, in areas where the impervious condition is most highly developed. This very striking difference in the perviousness of the soils in the extreme northern portion of the county compared with those in the middle and southern portions, is probably to be explained by difference in age and origin of the soil material. Most of the material which forms the soil in the extreme northern part of the county came from the north, while that which is distributed over the rest of the county is wind-blown material derived from sediments brought down by the Des Moines river from the Kansan drift sheet. This latter material was low in, or devoid of, lime, and appears to have been finer in texture than the sediments brought down from the north, which were derived from the Iowan glaciation.

The dark color of the prairie soils is due to the accumulation of organic matter, which is derived very largely from the roots of prairie grasses. The network of grass roots was protected from rapid and complete decay by the protective covering of fine, moist, soil material and by the mat of vegetative material formed by old grass stems and leaves, which was very effective in excluding the oxygen of the air. On the native prairies the stems and leaves of the grasses were usually burned in part or disappeared in part thru decay, so that they actually added little organic material to the soil; however, the protection afforded by this mat of decaying material was of importance in retarding the decay of the roots. From a sample of virgin sod of bluestem, one of the most common prairie grasses, it has been determined that an acre of this soil to a depth of 7 inches may contain as high as 13½ tons of roots.

Brown Silt Loam (226, 526)

Brown Silt Loam is the most extensive soil type in Hancock county. It covers an area of 255.08 square miles, or just about one-third of the area of the county. The difference in the origin of the soil material in the northern and southern parts of the county has resulted in two phases of Brown Silt Loam, one, found in the northern part of the county, having a silty, friable, indistinctly developed subsoil, and the other, found in the central and southern parts of the county, having a well-developed, clayey subsoil. A very small area of the morainal type (226) occurs in the southwestern part of the county just west of Tioga, in the form of a distinct north-south ridge.

There are small areas in the county which are mapped as Brown Silt Loam that have been recently invaded by forests; the invasion, however, has not been of sufficient duration to materially change the character of the soil. These forests generally consist of black walnut, wild cherry, hackberry, ash, hard maple, elm, and bur oak.

The surface soil of this type is a brown silt loam, usually with a grayish cast, and varies in depth from 8 to 16 inches. As the type approaches Brown-Gray Silt Loam On Tight Clay, the grayish cast becomes more pronounced, and where it approaches timber soils, the color becomes a yellowish brown. As a rule, the fine sand content increases as the river is approached. The subsurface is usually a yellowish or grayish brown, friable, silt loam, ranging from 6 to 18 inches in thickness. The subsoil to a depth of 35 to 40 inches is a mottled,

yellowish brown, or yellowish drab, fairly compact clay or silty clay, excepting in Durham township and vicinity, where it is a mottled, yellowish gray, friable silt loam. The organic-matter content of this type ranges from an amount that would be considered low for the type on the more rolling areas and near the timber soil areas, to a fair amount on the flat, more poorly drained areas.

Management.—This type is in fair physical condition. However, cropping practices which do not make provision for systematic and adequate additions of organic matter to the soil are gradually resulting in an increasingly poor physical condition. The type is acid, with the possible exception of a few areas, tho not strongly so. Results from the Carthage experiment field (see page 50) show that the use of limestone on this type is very profitable. Its use, moreover, makes the growth of alfalfa and sweet clover possible. Both of these crops are excellent in helping to keep the soil in good condition. The first application of limestone usually should be at the rate of 1 to 3 tons per acre. It is suggested that the exact rate of application be determined in consultation with the county farm adviser, or by correspondence with the Agricultural Experiment Station.

The evidence regarding the use of phosphates is not of such a nature that any definite recommendations can be made for this type in Hancock county. The use of rock phosphate on the Carthage field has resulted in an increase in the average yield of all crops, but the increases have not been large enough in either the grain or the live-stock system to pay for the phosphate. On a similar soil at Urbana (see page 48) with a corn, oats, clover, wheat rotation, rock phosphate has been used with excellent results in both the live-stock and the grain systems of farming after the second rotation. It is suggested that a trial be made of rock phosphate, at the rate of ½ ton per acre, for wheat, to be followed by clover. The large returns from the use of steamed bone meal on the Bloomington experiment field, which is located on a similar soil, suggest that, after the nitrogen deficiency has been taken care of, a more available phosphate, either steamed bone meal or acid phosphate, may be used at a profit (see page 55). If either of these phosphates is used, it should be drilled or otherwise well worked into the seed bed, as it is being prepared for wheat, at the rate of about 250 pounds of bone meal or 500 pounds of acid phosphate per acre. When used in these amounts, sufficient phosphorus will be added to the soil to maintain its phosphorus content, if all the hay grown and all the crop residues produced are returned to the soil, either directly or in the form of manure.

Brown-Gray Silt Loam On Tight Clay (528)

Brown-Gray Silt Loam On Tight Clay occurs in irregular and widely distributed areas in the southern two-thirds of the county. It comprizes 57.2 square miles, or 7.48 percent of the area of the county.

The surface soil, to a depth of 8 to 10 inches, is a brown or grayish brown silt loam. The organic-matter content varies as the type merges into other types, being greater where it approaches Brown Silt Loam (526) or Black Silt Loam On Clay (525.1) and less where it grades toward Yellow-Gray Silt Loam (534). The subsurface usually consists of two strata. The upper one to a depth of 15 to 17 inches is a gray or brownish gray silt loam which passes into a yellowish

gray, silty clay loam. This latter stratum passes into a very plastic clay subsoil, which varies greatly in color, but is usually a mottled, yellowish drab or brown, at 16 to 22 inches in depth. The heavy clay subsoil extends to a depth of 40 to 46 inches.

Management.—The flat topography and tight clay subsoil of this type make the drainage poor. Tile, in order to work efficiently, must be placed closer together than in soils having a more open subsoil. The strings should not be over 5 rods apart, and 3 or 4 rods would be better. This type is not strongly acid and ordinarily 2 tons of limestone per acre is sufficient to grow sweet clover. There is some variation, however, in the need for lime, depending upon the depth to which the acidity extends. Care should be taken to provide for frequent additions of fresh organic matter, particularly clovers. Sweet clover excels all others for increasing the producing power of this type of soil. The phosphorus content of this type is slightly less than that of Brown Silt Loam. While satisfactory experimental evidence is lacking regarding the use of phosphate on this soil type, yet a conservative statement would seem to be that rock phosphate at the rate of 1,000 pounds per acre, steamed bone meal at the rate of 150 pounds per acre, or acid phosphate at the rate of 300 pounds per acre used in the rotation on wheat to be followed by clover, would prove a profitable investment unless good applications of manure are being made, in which case it is doubtful whether the phosphates would cause sufficient increases in yield to pay for their cost. Bone meal and acid phosphate when used at the above rates will probably maintain the supply of phosphorus if all the organic materials are returned either directly or in the form of manure, and the use of rock phosphate at the above rate will result in a relatively rapid increase of phosphorus in the soil.

Black Silt Loam On Clay (525.1)

Black Silt Loam On Clay is widely distributed thruout the county and occurs chiefly in association with Brown-Gray Silt Loam On Tight Clay (528). It covers an area of 30.56 square miles, or 4 percent of the area of the county. In topography it is usually flat and the drainage is poor. The presence of the clay subsoil makes it more difficult to underdrain than either Brown Silt Loam or Black Clay Loam. This is especially true where it approaches Brown-Gray Silt Loam On Tight Clay (528).

The surface soil extending to a depth of about 10 inches, is black silt loam. It is well supplied with organic matter, and when well drained, is not difficult to keep in good tilth. It should be realized, however, that provision should be made for returning fresh organic matter at frequent intervals for it is much easier to keep this type in good physical condition than to restore it when once destroyed. The subsurface stratum varies from 8 to 14 inches in thickness. In color it varies from drabbish black to dark drabbish brown with a yellowish tint becoming evident near the bottom of the stratum. The subsoil begins at 17 to 24 inches, and is a plastic drab clay, strongly mottled with grayish yellow. It is inclined to be somewhat impervious.

Management.—Drainage is the first requirement of this type. For maintaining good tilth it is necessary to make systematic provision for adding fresh organic matter. In order to do this, a proper rotation of crops, which includes

clover, should be established, and the crop residues, together with one of the clover crops, should be turned under. In a live-stock system, manure will be an important source of organic matter, and the best possible use should be made of it. This will not only help in maintaining good tilth, but will also help conserve nitrogen and other elements of plant food. This type usually is not acid, and limestone is not advised unless careful tests, or observed failure of the clovers, show where the exceptions to the general rule occur.

Black Clay Loam (520)

Black Clay Loam is frequently called ''gumbo'' because of its sticky character. Its formation in the low places is due to the accumulation of organic matter and the washing in of clay and fine silt from the slightly higher adjoining lands. The type covers an area of 1.76 square miles. It occurs principally in Rock Creek township (Township 6 North, Range 7 West).

The surface soil extends to a depth of 8 to 12 inches and is a black, granular clay loam with an unusually low organic-matter content for this type of soil. The subsurface, 10 to 16 inches in thickness, is a drab or yellowish drab clay loam. It is pervious to water and is subject to a great deal of shrinkage in times of drouth. The subsoil is usually either a mottled drab or a mottled dull yellow clay or clay loam. As a rule the iron is not highly oxidized because of poor drainage. The checking and jointing in the sub-soil make it readily permeable to water and consequently rather easy to drain. The subsoil often contains a considerable amount of limestone in the form of concretions.

Management.—This type is well supplied with all the elements of plant food and is usually not acid. The important considerations in its management are: first, drainage; and second, provision for maintaining the nitrogen supply and organic-matter content by plowing down crop residues, and manure, and growing clovers. The high clay content of this soil makes it much more difficult to work than is the case with lighter soils and it is much more likely to get into such a condition that an excessive amount of tillage is required to form a good seed bed. The only way to avoid this danger is to keep up the organic-matter supply and to use care in all tillage operations.

Brown Fine Sandy Loam (871)

Brown Fine Sandy Loam occurs in the north-central and southwestern parts of the county.

The surface soil, which is about 8 inches deep, is brown fine sandy loam. It is fairly well supplied with organic matter. The subsurface is 8 to 14 inches in thickness and is yellowish gray fine sandy loam, becoming yellower with increasing depth. The subsoil is mottled yellow silt loam or clayey silt which is fairly compact and yet is pervious to roots and water.

Management.—This type, altho small in area, is an excellent soil. The nitrogen content is about the same as that of Brown Silt Loam, while the phosphorus content is slightly higher than is found in that type. Its management, however, should be practically the same as that recommended for Brown Silt Loam (see page 13).

(b) UPLAND TIMBER SOILS

The upland timber soils occur along streams and are characterized by a yellow, yellowish gray, or gray color, due to their low organic-matter content resulting from the long-continued growth of forest trees.

Yellow-Gray Silt Loam (234, 534)

Yellow-Gray Silt Loam occurs in the outer timber belts along streams. It is well distributed thruout the county, and covers an area of 166.24 square miles, or about one-fifth of the total area of the county. In topography, it is sufficiently rolling for good surface drainage without much tendency to wash if proper care is taken.

The surface soil is about 8 inches deep. It is a brownish gray, yellowish gray, or gray silt loam, having a floury feel. The more nearly level areas are gray in color, while the more rolling areas have a yellowish gray or brownish gray color. As the type approaches Brown Silt Loam or Brown-Gray Silt Loam On Tight Clay, it becomes decidedly darker. The organic-matter content varies considerably, but is low, as is always the case with timber soils in this region. The subsurface varies from 3 to 10 inches in thickness. It is a mottled gray, yellowish gray, or yellowish brown silt loam. The subsoil, extending to a depth of 17 to 36 inches, is a mottled yellow or grayish yellow clay loam, plastic when wet and rather impervious to water.

Management.—The first essential in the management of this type is limestone. Three to four tons of limestone per acre will probably be required for successful sweet clover growth. The second essential is to increase the nitrogen and organic-matter content of the soil. If a good rotation is adopted following the application of limestone, and full use is made of green manures, legume and other residues, and stable manure, this soil will respond by yielding very satisfactory crops, its tilth will be improved, and the tendency to wash on the more rolling areas will be lessened. The merits of sweet clover for use on this type are well known. A three-year rotation which includes sweet clover is excellent. Such a rotation might be corn, oats or soybeans, and wheat seeded with sweet clover. The sweet clover should be plowed down in the spring for corn. The surface soil of this type is somewhat lower in phosphorus than is Brown Silt Loam, the corresponding prairie type. However, the phosphorus content to a depth of 40 inches is as great as, or slightly greater than, that of Brown Silt Loam. Experiments at Raleigh, in Saline county, on soil which is very similar to much of this type as mapped in Hancock county indicate that it is very doubtful whether rock phosphate can be used at a profit. The crop increases following its use have been either very small or entirely lacking. Experiments with steamed bone meal on this type at Antioch in Lake county have shown a good profit from its use. The soil on the Antioch field, while mapped as Yellow-Gray Silt Loam, is somewhat different from this type as mapped in Hancock county; therefore considerable caution should be used in applying the Antioch field results to this type of soil in Hancock county. The well known response of wheat to available phosphates and of corn to potash salts on soils of this general character suggests that, in an experimental way in a rotation including these

crops, potassium chlorid or sulfate at the rate of 75 to 100 pounds per acre be applied at the time of, or immediately prior to, planting corn, unless manure has been applied to the corn ground; and that either acid phosphate at the rate of about 300 pounds per acre, or steamed bone meal at the rate of about 150 pounds per acre, be drilled in at the time of seeding wheat or broadcasted and well worked into the seed bed prior to drilling in the wheat. These suggestions presuppose that good soil management methods are being practiced, including the use of legumes, preferably sweet clover at least during the early period of the soil improvement program, and the return of all organic residues to the soil either directly or in the form of manure.

Results from the Raleigh and Antioch experiments may be found on page 57 of the Supplement.

Yellow Silt Loam (535)

In area, Yellow Silt Loam stands third among the soil types of Hancock county. It covers 146.08 square miles, or practically one-fifth of the area of the county. This type comprizes the hilly land, some of which is badly eroded, and all of which is subject to serious erosion, in the inner timber belt along streams, and is about as widely distributed as Yellow-Gray Silt Loam. It occurs frequently in narrow irregular strips with Yellow-Gray Silt Loam intervening. In most places it is so hilly that it should not be cultivated because of the danger of injury from washing.

The surface soil is a yellow or yellowish gray silt loam, pulverulent and mealy. It varies greatly in depth, owing to differences in the amount of soil removed by erosion. In some places the subsoil is exposed, while in others the surface is 7 or 8 inches deep. The organic-matter content is low, particularly where erosion, either sheet washing or gullying, is now active. The subsurface, where such a stratum is present, is a yellow silty clay loam and it varies in thickness from 0 to about 12 inches. The variation is due to the removal of all or part of the surface and subsurface by washing, which has resulted either in the exposure of the glacial till, or in its occurrence at varying depths below the surface. The subsoil is a compact, yellow clay.

Management.—In the management of Yellow Silt Loam, the most important consideration is that of preventing washing and gullying. Probably the best method of preventing washing is to leave the land in permanent bluegrass or in sweet clover pasture. If the land is cropped at all, a rotation should be practiced that will require a cultivated crop as little as possible, and allow pasture and meadow most of the time. Deep contour plowing should be practiced, and the planting and cultivating should be done on contours. Furrows should not be made up and down the slope. On much of this land the erosion problem may be solved by terracing. Every means should be employed to maintain and increase the organic-matter content of the soil. This will help in holding the soil and in keeping it in good physical condition so that it will absorb a larger amount of water and thus diminish the run-off.

Sweet clover is one of the best plants to grow on rolling land. It provides an abundance of excellent pasture and furnishes a large amount of nitrogen,

thus encouraging a more luxuriant growth of bluegrass. Cover crops should be kept on the land as much as possible. If gullies form, they should be filled with brush or straw to catch the sediment and prevent them from becoming deeper. Gullied land can be reclaimed by filling in the gullies with the plow and scraper, applying about 4 tons of crushed limestone per acre, and seeding to sweet clover. This should be done in the spring. The amount of work and cost involved in such a project should be carefully considered before attempting it. It should also be realized that constant watchfulness and the timely use of straw or cornstalks are necessary to prevent a recurrence of the eroded condition. (See Bulletin 207, Washing of Soils and Methods of Prevention.) In making plans for this rather extensive reclamation work terracing should be carefully considered. For methods of improving Yellow Silt Loam, see the discussion of the Vienna experiment field on page 60 of the Supplement.

Yellow-Gray Fine Sandy Loam (874)

Yellow-Gray Fine Sandy Loam is made up of the coarser material deposited by the wind near the bluff of the Mississippi bottoms. This type contains a large amount of very fine sand. It occupies a strip one to two miles wide on the bluff of the river. It cuts out near Warsaw and does not begin again until six miles north of Hamilton. It is generally true that along the Mississippi where the bottom land becomes very narrow, this wind deposit of deep loess is very narrow, and such is the case in Hancock county. This type occupies 14.96 square miles, or about 2 percent of the area of the county.

The surface soil, which is about 10 inches deep, is a grayish yellow fine sandy loam. The organic-matter content is low, particularly where recent erosion has removed some of the surface soil. The subsurface varies from 6 to 12 inches in thickness, and consists of a mottled, yellowish gray fine sandy silt loam that becomes slightly heavier with increasing depth. The subsoil to a depth of 35 to 40 inches, is a mottled, yellow, silty clay loam, rather compact, but pervious. When it becomes dry it is very difficult to penetrate. At depths of 35 to 40 inches, a friable silt loam is encountered. This material is mottled drab in color and contains numerous yellow spots.

Management.—In the management of Yellow-Gray Fine Sandy Loam, the most important consideration is the increase of the organic-matter content. This is necessary in order to supply nitrogen and to liberate mineral plant food, as well as to give better tilth, to lessen the tendency to run together, to increase the power of the soil for absorbing moisture, and on some of the more rolling phases, to lessen washing. A systematic rotation should be practiced in which legumes are grown every two or three years, primarily for soil improvement. The legumes and crop residues should be turned under either directly or as manure.

The nitrogen content is low. The rotation that is practiced should be planned with a view to supplying this element which is now the limiting factor in crop yields. Sweet clover could be grown with very great profit on this type, for this purpose, especially if the seed alone is taken off and all of the growth turned under, or if it is turned under for corn in the spring of the second year.

This type is acid and contains no carbonates in the deeper subsoil. About 3 tons of limestone per acre should be applied with subsequent applications of about 2 tons per acre as needed.

The supply of phosphorus is very satisfactory and the type is rich in potassium. This is a good alfalfa soil and after the nitrogen and organic-matter supplies have been increased following the application of limestone, it becomes a productive soil for any of the ordinary field crops.

Yellow Fine Sandy Loam (875)

Yellow Fine Sandy Loam occurs adjacent to the Mississippi bottom, and occupies the hilly and very rolling land. This type is so badly broken that but little of it can be cultivated at a profit. The areas of this type are very irregular, consisting of arms extending out into the upland along the creeks and gullies. It is of very little value except for pasture. The type covers 16.08 square miles, or about 2 percent of the area of the county.

The character of the surface, subsurface, and subsoil varies greatly because erosion is more active in some places than in others. The fine sandy loam or deep loess varies from 4 to 40 or more feet in depth. It is acid to a depth of 4 to 15 feet. The color of the surface is usually a reddish yellow. The subsoil at a depth of about 20 inches is a compact, slightly mottled, grayish yellow fine sandy silt loam. In places where erosion is removing the soil material rapidly, this compact subsoil stratum is not found.

Management.—The rough, broken topography of this type makes it inadvisable to attempt to cultivate it. It should be kept in permanent pasture or in timber.

Light Gray Silt Loam On Tight Clay (532)

Light Gray Silt Loam On Tight Clay occupies 2.68 square miles, or .35 percent of the area of the county. It occurs in small isolated areas scattered thruout the county, principally on the divides. The topography is very flat and rather poorly drained, altho not swampy.

The surface soil to a depth of about 7 inches, is a light brownish gray silt loam. In the virgin condition, the surface one or two inches contains enough organic matter to give it a brown color, but beneath this the soil is white and almost devoid of organic matter. Small, rounded, black iron concretions, varying from the size of a mustard seed to that of a pea, are usually present. The organic-matter content is very low. The subsurface is a gray to light gray, very silty material varying from 10 to 12 inches in thickness. It passes abruptly into the subsoil which is a mottled, drab or dull yellow clay. This stratum is very impervious to both air and water.

Management.—This type is very low in organic matter and is more acid than adjoining types. The soil runs together badly, and does not retain moisture well. In the management of the type, ground limestone should be used at the rate of about 4 tons per acre. The phosphorus content is low in the surface soil. However, the physical condition of this type is so poor and the nitrogen content is so low that it is not likely that phosphates could be used at a profit. The use of rock phosphate on the Sparta field, which is located on this type of

soil, has not resulted in increased yields. The use of limestone and residues or manure has given good increases. All crop residues should be turned under directly or in manure, and sweet clover should be grown and practically the entire crop, with the exception of the seed, turned back into the soil. All available farm manure should be put on the land with the least possible loss. Pasturing is one of the best uses that can be made of this land, especially if seeded to sweet clover.

(c) TERRACE SOILS

The terrace soils occur in the sharp bend of the Mississippi river at Nauvoo. At one time the Mississippi flowed at a higher level than at present, but when its course was changed, a ledge of rock was left above the river sufficiently high so that this does not overflow. A layer of soil material has been formed on the rock thru deposition by water and wind, and this now constitutes the terrace soil. It is not a terrace of the ordinary method of formation, but it represents a shelf considerably below the upland.

Black Clay Loam On Rock (1520.5)

Black Clay Loam On Rock covers an area of only 77 acres. It is of very little value from an agricultural standpoint. It consists of black clay loam resting on rock at a depth of 16 to 24 inches.

Brown Sandy Loam On Rock (1560.5)

Brown Sandy Loam On Rock occurs at a slightly higher level than the Black Clay Loam On Rock. It covers an area of only 179 acres and is located in the same region as the preceding type. It is of no great importance from an agricultural standpoint. The soil consists of a dark brown sandy loam resting on rock at a depth of 18 to 26 inches.

(d) OLD SWAMP AND BOTTOM-LAND SOILS

The Illinoisan is one of the oldest glaciations in the state, and the bottom lands within its borders are mapped as old bottoms. The age or maturity of these bottoms is indicated in some places by the character of the soil. In some small areas rather tight clay subsoils have been developed, but this is true only occasionally. A distinct surface, subsurface, and subsoil development is, however, rarely found in bottom-land soils. Altho the bottom lands in Hancock county are somewhat variable, they are mostly silt loams, with the exception of those in the south-central and north-central parts of the county.

Deep Brown Silt Loam (1326)

Deep Brown Silt Loam is widely distributed along the streams and comprizes a very large part of the bottom lands in the eastern part of the county. It occurs as narrow strips in the bottoms of the valleys, varying from a few rods to a mile or more in width. It covers altogether an area of 29.36 square miles, or 3.84 percent of the area of the county.

The surface soil is a brown to light brown silt loam with a medium organic-matter content. There is a gradual change to a clayey silt loam beginning at 10 to 14 inches in depth. The color also changes gradually to a drabbish brown between about 12 and 22 inches, and then becomes a mottled, yellowish brown.

Management.—The chief points to be kept in mind in the management of this type other than good tillage, are the addition of 1 to 2 tons of limestone per acre and the growth of legumes to increase the nitrogen content of the soil, which is low. It is not likely that phosphates of any kind could be used at a profit because of the depth to which plant roots are able to penetrate on this type.

Mixed Loam (1354)

Mixed Loam is confined to the bottom lands of the north-central and south-central parts of the county. Bottom lands which are mapped as this type are so variable that it is not possible to separate out and map the various types which actually occur. They are, therefore, grouped together and called Mixed Loam. In texture the surface soil of this type varies from sand to silty clay loam, and in color from black to light brown with occasional small areas having a gray tint.

(e) LATE BOTTOM-LAND SOILS

Bottom-land soils which occur in the Mississippi bottoms and in the smaller stream valleys of the adjoining bluffs of the deep loess area are mapped as late bottoms.

Brown Silt Loam (1426)

Brown Silt Loam occurs in the Mississippi bottom south of Warsaw. It is formed by deposit from the Mississippi river. It covers an area of 10.88 square miles, or 1.42 percent of the area of the county.

The surface soil is a brown silt loam varying on the one hand to a sandy loam and on the other to a silty clay loam. At a depth of 8 to 12 inches the color begins to change gradually to a drabbish brown and at 20 to 25 inches it becomes a drabbish yellow. As a rule, the texture gradually grows finer with increasing depth. However, there is more variation in the subsoil than in the surface, and not infrequently pure sand is found in the subsoil.

Management.—This type is very fertile. Areas which are protected by levees from all overflow are becoming acid. The only management requirements of this type are limestone where needed, the growth and handling of legumes in such a way as to maintain the nitrogen and organic matter, and good tillage.

Drab Clay (1415)

Drab Clay consists of very fine soil material deposited in what is commonly spoken of as "back-water", where there is very little current. This type covers an area of 7.76 square miles, or about 1 percent of the area of the county.

The surface soil is a drab clay, granular when dry and plastic when wet. It is fairly well supplied with organic matter. It sometimes has a noticeable

amount of sand or gravel. At about 10 inches in depth, the color becomes dark drab with brown mottlings of iron oxide. At a depth of 25 to 30 inches a yellowish tint usually appears.

Management.—In the management of this type, it is very essential that the organic matter be maintained as an aid in keeping the soil in good tilth. It is well to use legumes in so far as is possible as a source of organic matter in order to provide for maintaining the nitrogen supply. About 2 tons of limestone per acre is usually necessary on this type to grow sweet clover.

Brown Sandy Loam (1460)

Considerable Brown Sandy Loam occurs in the northern part of the county as well as in the bottom land south of Warsaw. It comprizes 7.88 square miles, or about 1 percent of the area of the county.

The surface soil is a brown sandy loam varying from light brown to almost black, owing to the varying content of organic matter. It also varies in sand content from a sand to a silt loam and, as a general rule, the sand content varies considerably within small areas. The color gradually becomes a yellowish brown and finally yellow at a depth of about 25 to 30 inches. The texture varies considerably but as a rule becomes a little finer with increasing depth.

Management.—If overflow does not take place in this type, it will be necessary to turn under organic matter and legumes for maintaining the nitrogen supply, as the total amount of this element is not high. Since the soil is somewhat acid, unless subject to overflow, it would be well to apply about 1 ton of limestone per acre to get the best results with legumes, especially with sweet clover.

Mixed Loam (1454)

Mixed loam occurs almost entirely outside of the levee and is of very little agricultural value. The total area covered by this type is 2.36 square miles, or .31 percent of the area of the county. It is a mixture of all sorts of constituents. There are areas that are very sandy, while others may be very heavy. Practically none of it is under cultivation.

Yellow Fine Sandy Loam (1475)

Yellow Fine Sandy Loam is formed by the wash from the deep loess area of the upland adjoining the bottom land. The total area comprizes 3.84 square miles, or .5 percent of the area of the county.

The surface soil is a yellowish to yellow-brown fine sandy loam. It is low in organic matter as indicated by the color. Very little change is discernible with increasing depth except that the yellow color becomes more pronounced.

Management.—This type, tho not high in nitrogen, will grow excellent crops. If overflow is discontinued, it will be necessary to make provision for maintaining or even increasing the supply of nitrogen. This can be done with clover and other legume crops, provided that the larger part of the crop, or the manure produced from it, is turned back into the soil. There is a large amount of limestone present in all strata of the soil and phosphate fertilizers are not needed.

Brown Silt Loam On Sand (1426.2)

Only one area of Brown Silt Loam On Sand was mapped, and that in the southwestern part of the county, just inside the levee in Sections 18 and 19, Township 3 North.

The surface soil is a brown silt loam varying somewhat in sand content, and is fairly well supplied with organic matter. At a depth of about 12 inches, light brown sandy silt loam is encountered and this rests on sand at a depth varying from 16 to 24 inches.

River Sand (1480)

A small area of River Sand, comprizing 205 acres, is found just south of Warsaw. While it is a river deposit, yet it has been reworked to a certain extent by the wind, thru which process some small, low dunes have been formed. It is light brown of yellowish brown sand in the surface and passes into yellow sand at 8 to 12 inches.

Management.—This type is adapted to special crops, such as melons. It usually is not acid. Nitrogen is very deficient and must be supplied by applications of manure or by the turning under of legumes; or in case highly specialized crops are grown, complete commercial fertilizers which are high in nitrogen may be used at a profit.

Drab Clay On Sand (1415.3)

Drab Clay On Sand is found only in the southern part of the Mississippi bottom-land area in Sections 33 and 34, Township 3 North. Doubtless a large part of these bottom lands have sand as the deeper subsoil. In the case of this type, the sand comes near enough to the surface so that it is taken into account in our classification. The total area of this type is 384 acres.

The surface soil is a drab clay, granular when dry, and plastic when wet, resembling the surface of the type, Drab Clay (1415), altho it may contain a larger percentage of sand. It is fairly well supplied with organic matter. Sand is found at 16 to 30 inches in depth.

Management.—The type is well supplied with nitrogen and phosphorus and with the turning under of ordinary residues, the nitrogen and organic matter can be maintained. The soil is slightly acid, and for best results with legumes, especially sweet clover and alfalfa, it may be necessary to apply 1 ton of limestone per acre.

(f) RESIDUAL SOILS

No soil areas have been found that are formed from the decomposition of rocks in place. There are, however, numerous outcrops of limestone in the county containing large numbers of silicious formations such as geodes.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to intelligently interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification used.

The type is the unit of classification and each type has definite characteristics. In establishing types, the following factors are taken into account: the character of the horizons composing the soil as to depth and thickness, physical composition, structure, organic-matter content, color, reaction, and carbonate content; the topography; the native vegetation; and the geological origin of the soil.[1]

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made whenever the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

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[1] Since some of the terms used in designating the factors which are taken into account in establishing soil types are technical in nature, the following explanations are introduced:

Horizon. A layer or stratum of soil which differs discernibly from those adjacent in color, texture, structure, chemical composition, or a combination of these characteristics, is called an horizon.

Depth and Thickness. The horizons or layers which make up the soil profile vary in depth and thickness. These variations are distinguishing features in the separation of soils into types.

Physical Composition. The physical composition, sometimes referred to as "texture," is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents: clay, silt, fine sand, sand, gravel, stones, and organic material.

Structure. The term "structure" has reference to the aggregation of particles within the soil mass and carries such qualifying terms as open, granular, compact.

Organic-Matter Content. The organic matter of soil is derived mainly from plant tissue and it exists in a more or less advanced stage of decomposition. Organic matter constitutes the predominating constituent in certain soils of swampy formation.

Color. Color is determined to a large extent by the proportion of organic matter, but at the same time it is modified by the mineral constituents, especially by iron compounds.

Reaction. The term "reaction" refers to the chemical state of the soil with respect to acid or alkaline condition. It also involves the idea of degree, as strongly acid or strongly alkaline.

Carbonate Content. The carbonate content has reference to the calcium carbonate (limestone) present, which in some cases may be associated with magnesium or other carbonates. The depth at which carbonates are found may become a very important factor in determining the soil type.

Topography. Topography has reference to the lay of the land, as level, rolling, hilly, etc.

Native Vegetation. The vegetation or plant growth before being disturbed by man, as prairie grasses and forest trees, is a feature frequently recognized in determining soil types.

Geological Origin. Geological origin involves the idea of character of rock materials composing the soil as well as the method of formation of the soil.

Classifying Soil Types.—In the system of classification used, the types fall first into four general groups based upon their geological relationships; namely, upland, terrace, swamp and bottom land, and residual. These groups may be subdivided into prairie soils and timber soils, altho as a matter of fact this subdivision is applied in the main only to the upland group. These terms are all explained in the foregoing part of the report in connection with the description of the particular soil types.

Naming and Numbering Soil Types.—In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a more or less definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise types names which are adequately descriptive, because the profile of mature soils is usually made up of four or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "on," and when its depth exceeds 30 inches, by the word "over"; for example, Brown Silt Loam On Gravel, and Brown Silt Loam Over Gravel.

As a further step in systematizing the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been assigned an index number. The names of the areas together with their general location and their corresponding index numbers are given in the following list.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* comprizing three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciations
300 *Lower Illinoisan glaciation,* covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* found in the older or Illinoisan glaciation
1400 *Late river-bottom and swamp lands,* those of the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan

For further information regarding these geological areas the reader is referred to the general map published in Bulletins 123 and 193.

Another set of index numbers is assigned to the classes of soils as based upon physical composition. The following list contains the names of these classes with their corresponding index numbers.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the balance of the number designates the type. To illustrate: the number 1126 means Brown Silt Loam in the early Wisconsin glaciation, 434 means Yellow-Gray Silt Loam of the middle Illinoisan glaciation. These numbers are especially useful in designating very small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports in connection with the maps.

SOIL SURVEY METHODS

Mapping of Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. The field work is done by parties of two to four men each. The field season extends from early in April to Thanksgiving. During the winter months the men are engaged in preparing a copy of the soil map to be sent to the lithographer, a copy for the use of the farm adviser until the printed map is available, and a third copy for use in the office in order to preserve the original official map in good condition.

An accurate base map for field use is necessary for soil mapping. These maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as the basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil type boundaries, together with the streams, roads, railroads, canals, town sites, and rock and gravel quarries are placed in their proper location upon the map while the mapper is on the area. With the rapid development of road improvement during the past few years, it is almost inevitable that some recently established roads will not appear on the published soil map. Similarly, changes in other artificial features will occasionally occur in the interim between the preparation of the map and its publication. The detail or minimum size of areas which are shown on the map varies somewhat, but in general a soil type if less than five acres in extent is not shown.

A soil auger is carried by each man with which he can examine the soil to a depth of 40 inches. An extension for making the auger 80 inches long is taken

by each party, so that the deeper subsoil may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by a speedometer or other measuring device, while distances in the field away from the roads are measured by pacing.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. The samples for this purpose are usually taken in three depths; namely, 0 to 6⅔ inches, 6⅔ to 20 inches, and 20 to 40 inches, as explained in connection with the discussion of the analytical data on page 7.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. A fact of equal importance, not so generally recognized, is that they also differ in other characteristics such as response to fertilizer treatment and to management.

The soil is a dynamic, ever-changing, exceedingly complex substance made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, the soil cannot be considered as a reservoir into which a given quantity of an element or elements of plant food can be poured with the assurance that it will respond with a given increase in crop yield. In a similar manner it cannot be expected to respond with perfect uniformity to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance favorable for the growth of the higher plants and of the beneficial microorganisms. Good soil management under humid conditions involves the adoption of those tillage, cropping, and fertilizer treatment methods which will result in profitable and permanent crop production on the soil type concerned.

The following paragraphs are intended to state in a brief way some of the principles of soil management and treatment which are fundamental to profitable and continued productivity.

CROP REQUIREMENTS WITH RESPECT TO PLANT-FOOD MATERIALS

Ten different elements of plant food are essential for the growth and formation of every plant. These elements are: *carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, magnesium, calcium, and iron.* Some seasons in central Illinois are sufficiently favorable to allow the production of at least 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. When such crops, growing under favorable climatic and cultural conditions and uninjured by disease or insect pests, are not produced the failure is due to unfavorable soil condition, which may result from poor drainage, poor physical condition, or from an actual deficiency in one or more of the elements of plant food.

TABLE A.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce: Kind	Produce: Amount	Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain.....	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw.....	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain.......	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover......	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs........	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain.......	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw........	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed.......	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay.......	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed.....	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay.....	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay.......	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1]These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

Table A shows the requirements of some of our most common field crops with respect to the seven plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of any element removed from an acre of land by a crop of a given yield can easily be computed.

SUPPLY OF PLANT-FOOD ELEMENTS

Of the ten elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and seven from the soil. Nitrogen, one of these seven elements obtained from the soil by all plants, may also be secured from the air by the class of plants known as legumes, in case the amount liberated from the soil is insufficient; but even these plants, which include only the clovers, peas, beans, and vetches among our common agricultural plants, are dependent upon the soil for the other six elements (phosphorus, potassium, magnesium, calcium, iron, and sulfur), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to nearly 33,000 pounds. In like manner the phosphorus content varies from about 420 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor

TABLE B.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	...	...
Sodium nitrate	310	...	...
Ammonium sulfate	400	...	...
Raw bone meal	80	180	...
Steamed bone meal	20	250	...
Raw rock phosphate	...	250	...
Acid phosphate	...	125	...
Potassium chlorid	...	...	850
Potassium sulfate	...	...	850
Kainit	...	...	200
Wood ashes[3] (unleached)	...	10	100

[1]See footnote to Table A.
[2]Young second year's growth ready to plow under as green manure.
[3]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

of production, then we must look for some outside source of supply. Table B is presented for the purpose of furnishing information regarding the quantity of some of the more important plant-food elements contained in materials most commonly used as sources of supply.

LIBERATION OF PLANT-FOOD ELEMENTS

The chemical analysis of the soil gives the invoice of plant-food elements actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such elements as calcium and phosphorus, converting them into available forms for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral elements are liberated for

the benefit of the cereal crops which follow in the rotation. Moreover, as an effect of the deep-rooting habit of these legumes, mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and supplies calcium, thus encouraging the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the unavailable organic nitrogen into available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium compounds.

Organic Matter and Biological Action.—Organic matter may be supplied thru animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant-food materials than the 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the ratio of carbon to nitrogen. Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing available phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant-food elements by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant-food materials are concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than

this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter, and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement.

Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands. Remarkable success has been experienced with limestone used in conjunction with sweet clover in the reclamation of abandoned hill land which had been ruined thru erosion.

Amounts to Apply.—If the soil is acid, usually at least 2 tons per acre of ground limestone should be applied as an initial treatment. Continue to apply limestone from time to time according to the requirement of the soil as indicated by the tests described below, or until the most favorable conditions are established for the growth of legumes, using preferably at times magnesian limestone ($CaCO_3MgCO_3$), which contains both calcium and magnesium and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone ($CaCO_3$). On strongly acid soils, or on land being prepared for alfalfa, 4 or 5 tons per acre of ground limestone may well be used for the first application.

How to Ascertain the Need for Limestone.—One of the most reliable indications as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover and alfalfa. These crops do not thrive in acid soils. Their successful growth, therefore, indicates the lack of sufficient acidity in the soil to be harmful. In case of their failure to grow the soil should be tested for acidity as described below. A very valuable test for ascertaining the need of a soil for limestone is found in the potassium thiocyanate test for soil acidity. It is of value to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonate of calcium and magnesium. The natural occurrence of these carbonates in the

soil is sufficient assurance that no limestone is needed, and the acidity test will be negative. On lands which have been treated with limestone, however, the surface soil may give a positive test for carbonates, due to the presence of undecomposed pieces of limestone, and at the same time a positive test for acidity may be secured. Such a result means either that insufficient limestone has been added, or that it has not been in the soil long enough to entirely correct the acidity. In making these tests, it is desirable to examine samples of soil from different depths, since carbonates may be present, even in abundance, below a surface stratum that is acid. Following are the directions for making the tests:

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol (not denatured). When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. In testing, therefore, the sample should be about as dry as when the soil is in good tillable condition. The conditions for a prompt reaction require a temperature that is comfortably warm.

The Hydrochloric Acid Test for Carbonates. Make a shallow cup of a ball of soil and pour into it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence, and indicates that the soil contains limestone or some other carbonate. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen usually costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for plant growth. These are the chemical and the biological fixation of the atmospheric nitrogen. Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of those legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for feed and seed as well as for fixing atmospheric nitrogen, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen will ever be able to replace the simple method

of obtaining atmospheric nitrogen by growing inoculated legumes in the production of our great grain and forage crops.

It may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpea hay contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of the soil is dependent upon the origin of the soil. The removal of phosphorus by continuous cropping slowly reduces the amount of this element in the soil available for crop use, unless its addition is provided for by natural means, such as overflow, or by agricultural practices, such as the addition of phosphatic fertilizers and rotations in which deep-rooting, leguminous crops are frequently grown.

It should be borne in mind in connection with the application of phosphate. or of any other fertilizing material, to the soil, that no benefit can result until the need for it has become a limiting factor in plant growth. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different materials containing phosphorus which are applied to land as fertilizer. The more important of these are bone meal, acid phosphate, natural raw rock phosphate, and basic slag. Obviously that carrier of phosphorus which gives the most economical returns, as considered from all standpoints, is the most suitable one to use. Altho this matter has been the subject of much discussion and investigation the question still remains unsettled. Probably there is no single carrier of phosphorus that will prove to be the most economical one to use under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

Bone meal, prepared from the bones of animals, appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the

phosphorus, a considerable percentage of nitrogen which adds a useless expense if the material is purchased only for the sake of the phosphorus. As a source of phosphorus, steamed bone meal is preferable to raw bone meal. Steamed bone meal is prepared by extracting most of the nitrogenous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate containing about 10 to 12 percent of the element phosphorus.

Acid phosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. Acid phosphate also contains besides phosphorus, sulfur, which is likewise an element of plant food. The phosphorus in acid phosphate is more readily available for absorption by plants than that of raw rock phosphate. Acid phosphate of good quality should contain 6 percent or more of the element phosphorus.

Rock phosphate, sometimes called floats, is a mineral substance found in vast deposits in certain regions. The phosphorus in this mineral exists chemically as tri-calcium phosphate and a good grade of the rock should contain 12½ percent, or more, of the element phosphorus. The rock should be ground to a powder, fine enough to pass thru a 100-mesh sieve, or even finer.

The relative cheapness of raw rock phosphate, as compared with the treated or acidulated material, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in this form than in the form of acid phosphate, the ratio being, under the market conditions of the past several years, about 4 to 1. That is to say, under these market conditions, a dollar will purchase about four times as much of the element phosphorus in the form of rock phosphate as in the form of acid phosphate, which is an important consideration if one is interested in building up a phosphorus reserve in the soil. As explained above, more very carefully conducted comparisons on various soil types under various cropping systems are needed before definite statements can be given as to which form of phosphate is most economical to use under any given set of conditions.

Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag phosphate is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore it tends to influence the soil reaction.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating the phosphorus from raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using acid phosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount

to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, which are silt loams and clay loams, are well stocked with potassium, altho it exists largely in a slowly soluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be supplied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of common soils are concerned, that, with a few exceptions, the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part, perhaps, because the potassium removed in the crops is mostly returned in the manure if properly cared for, and perhaps in larger part because the decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no plant-food elements of value.

In considering the conservation of potassium on the farm it should be remembered that in average live-stock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in live-stock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by the actual crop requirements for plant food, magnesium and calcium are more limited in some Illinois soils than potassium. But with these elements we must consider also the loss by leaching.

The annual loss of limestone from the soil depends, of course, upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of lime materials from the soil, it is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

Limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur

in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply to conditions in Illinois.

Physical Improvement of Soils

In the management of most soil types, one very important matter, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, slightly retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is undergoing destruction during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, corn stalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and corn stalks should be turned under, and not burned. There is considerable evidence indicating that on some soils undecomposed straw applied in excessive amount may be detrimental. Probably the best practice is to apply the straw as a constituent of well-rotted stable manure. Perhaps no form of organic matter acts more beneficially in producing good tilth than corn stalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of corn stalks is one and one-half times that of a ton of manure, and a ton of dry corn stalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the corn stalks during the winter and often rather late in the spring after the frost is out of the ground. This tramping by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too

late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The effect becomes worse if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including, for the reasons discussed above, a liberal use of legumes. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations, applicable to the corn belt, which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover), or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in live-stock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be seeded four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. Or, in some cases, it may become desirable to divide the acreage of small grain and grow in the same year more than one kind. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields on Soil Types Similar to those Occurring in Hancock County)

In the earlier reports of this series it was the practice to incorporate in the body of the report the results from certain experiment fields, for the purpose of illustrating the possibilities of improving the soil of various types. The information carried by such data must, naturally, be considered more or less tentative. As the fields grow older new facts develop, which in some instances may call for the modification of former recommendations. It has therefore seemed desirable to separate this experiment field data from the more permanent information of the soil survey, and embody the same in the form of a supplement to the soil report proper, thus providing a convenient arrangement for possible future revisions as further data accumulate.

The University of Illinois has operated altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the summarized results from certain of these fields located on types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, live-stock farming and grain farming.

In the live-stock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as corn stalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It is the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the live-stock system.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a rather definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system*.

Mineral Manures.—The yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, usually 200 pounds of kainit. When kainit was not available, owing to conditions brought on by the World war, potassium carbonate was used. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

BROWN SILT LOAM

Several experiment fields have been conducted on Brown Silt Loam at various locations in Illinois. Those located at the University have been in operation the longest and they serve well to illustrate the principles involved in the maintenance and improvement of this type of soil.

The Morrow Plots

It happens that the oldest soil experiment field in the United States is located on typical Brown Silt Loam of the early Wisconsin glaciation, on the campus of the University of Illinois. This field was started in 1879 by George E. Morrow, who for many years was Professor of Agriculture, and these plots are known as the Morrow plots.

The Morrow series now consists of three plots divided into halves and the halves are subdivided into quarters. On one plot corn is grown continuously; on the second, corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904. Besides farm manure, phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. At the same time the rate of subsequent application of both forms of phosphorus was reduced to one-fourth the quantity, or to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per year. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre.

Table 1 gives the yearly records of the crop yields from the Morrow plots, and Table 2 presents the results in summarized form.

FIG. 1.—CORN ON THE MORROW PLOTS IN 1910

TABLE 1.—URBANA FIELD, MORROW PLOTS: BROWN SILT LOAM; PRAIRIE; EARLY WISCONSIN GLACIATION

Annual Crop Yields in Soil Experiments—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
		Corn	Corn	Oats	Corn	Oats	Clover
1879–87	None.............	....	....	....	....	....	....
1888	None.............	54.3	49.5	....	....	48.6	....
1889	None.............	43.2	....	37.4	....	....	(4.04)
1890	None.............	48.7	54.3	....	....	....	(1.51)
1891	None.............	28.6	33.2	....	....	....	(1.46)
1892	None.............	33.1	....	37.2	70.2	....	....
1893	None.............	21.7	29.6	....	34.1	....	....
1894	None.............	34.8	....	57.2	....	65.1	....
1895	None.............	42.2	41.6	....	....	22.2	....
1896	None.............	62.3	....	34.5	....	....	....
1897	None.............	40.1	47.0	....	....	....	....
1898	None.............	18.1	....	....	....	....	....
1899	None.............	50.1	44.4	....	53.5	....	....
1900	None.............	48.0	....	41.5	....	....	....
1901	None.............	23.7	33.7	....	34.3	....	....
1902	None.............	60.2	....	56.3	....	54.6	....
1903	None.............	26.0	35.9	....	....	....	(1.11)
1904	None.............	21.5	....	17.5	55.3	....	....
1904	MLP.............	17.1	....	25.3	72.7	....	....
1905	None.............	24.8	50.0	....	....	42.3	....
1905	MLP.............	31.4	44.9	....	....	50.6	....
1906	None.............	27.1	....	34.7	....	....	(1.42)[1]
1906	MLP.............	35.8	....	52.4	....	....	(1.74)[1]
1907	None.............	29.0	47.8	....	80.5	....	....
1907	MLP.............	48.7	87.6	....	93.6	....	....
1908	None.............	13.4	....	32.9	....	40.0	....
1908	MLP.............	28.0	....	45.0	....	44.4	....
1909	None.............	26.6	33.0	....	....	....	(.65)[2]
1909	MLP.............	31.6	64.8	....	....	....	(1.73)[3]
1910	None.............	35.9	....	33.8	58.6	....	....
1910	MLP.............	54.6	....	59.4	83.3	....	....
1911	None.............	21.9	28.6	....	....	20.6	....
1911	MLP.............	31.5	46.3	....	....	38.0	....
1912	None.............	43.2	....	55.0	....	....	16.3[1]
1912	MLP.............	64.2	....	81.0	....	....	20.0[1]
1913	None.............	19.4	29.2	....	33.8	....	....
1913	MLP.............	32.0	25.0	....	47.8	....	....
1914	None.............	31.6	....	33.6	....	39.6	....
1914	MLP.............	39.4	....	58.2	....	60.4	....
1915	None.............	40.0	49.0	....	....	....	24.2[1]
1915	MLP.............	66.0	81.2	....	....	....	27.1[1]
1916	None.............	11.2	....	37.5	27.8	....	....
1916	MLP.............	10.8	....	64.7	40.6	....	....
1917	None.............	40.0	48.4	....	....	68.4	....
1917	MLP.............	78.0	81.4	....	....	86.9	....
1918	None.............	13.6	....	27.2	....	....	(2.58)
1918	MLP.............	32.6	....	59.3	....	....	(4.04)
1919	None.............	24.0	30.8	....	52.2	....	....
1919	MLP.............	43.4	66.2	....	70.8	....	....
1920	None.............	28.2	....	37.2	....	52.2	....
1920	MLP.............	54.4	....	51.6	....	69.7	....
1921	None.............	19.8	30.6	....	....	....	(.26)[4]
1921	MLP.............	42.2	68.4	....	....	....	(1.33)[5]
1922	None.............	24.6	....	39.3	49.2	....	....
1922	MLP.............	39.4	....	55.8	65.3	....	....
1923	None.............	15.0	17.2	....	....	53.4	....
1923	MLP.............	31.4	46.4	....	....	66.6	....

[1]Soybeans.
[2]In addition to the hay, .64 bushel of seed was harvested.
[3]In addition to the hay, 1.17 bushels of seed were harvested.
[4]In addition to the hay, .53 bushel of seed was harvested.
[5]In addition to the hay, .85 bushel of seed was harvested.

TABLE 2.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY

Average Annual Yields—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover
		16 crops	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
1888 to 1903	None........	39.7	41.0	44.0	48.0	47.6	(2.03)
		20 crops	*10 crops*	*10 crops*	*7 crops*	*7 crops*	*4 crops*
1904 to 1923	None........	25.5	36.5	34.9	51.1	45.2	(1.23)[1]
	MLP........	40.6	61.2	55.3	67.7	59.5	(2.21)[1]

[1]One crop of soybean hay included.

Summarizing the data from these Morrow plots into two periods with the second period beginning in 1904 when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the untreated continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oats production, while the averages for the three-year system show an increase in corn yield and decreases in oats and clover. Unfortunately the numbers of crops included in these last averages are too small to warrant positive conclusions.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

The Davenport Plots

Another set of plots on the University campus at Urbana, forming a more extensive series than the Morrow plots, but of more recent origin, are the Davenport plots. Here provision is made for each crop in the rotation to be represented every year. These plots were laid out in 1895, but special soil treatment was not begun until 1901. They now comprize five series of ten plots each, and each series constitutes a "field" in a crop rotation system.

From 1901 to 1911 three of the series were in a three-year rotation system of corn, oats, and clover, while the remaining two series rotated in corn and oats. In 1911 these two systems were combined into a five-series field, with a crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field. The alfalfa occupies one series during a rotation of the other four crops, shifting to another series in the fifth year, thus completing the cycle of all series in twenty-five years.

The soil treatment applied to these plots has been as follows:

Legume cover crops were seeded in the corn at the last cultivation on Plots 2, 4, 6, and 8, from 1902 to 1907, but the growth was small and the effect, if any, was to decrease the returns from the regular crops. Crop residues (**R**) have been returned to these same plots since 1907. These consist of stalks and straw, and all legumes except alfalfa hay and the seed of clover and soybeans. Beginning in 1918 a modification of the practice was made in that one cutting of the red clover crop is harvested as hay. In conjunction with these residues a catch crop of sweet clover grown with the wheat is plowed under.

Manure (**M**) was applied preceding corn, at the rate of 2 tons per acre per year in 1905, 1906, and 1907; subsequently as many tons have been applied as there have been tons of air-dry produce harvested from the respective plots.

Lime (**L**) was applied on Plots 4 to 10 at the rate per acre of 250 pounds of air-slaked lime in 1902, and 600 pounds of limestone in 1903. No further application was made until 1911, when the system of cropping was changed. Since that time applications of limestone have been made at the rate of one-half ton per acre per year.

Phosphorus (**P**) was applied on Plots 6 to 9 at the rate of 25 pounds per acre per annum in 200 pounds of steamed bone meal; but beginning with 1908 rock phosphate at the rate of 600 pounds per acre per annum was substituted for the bone meal on one-half of each of these plots. These applications continued until 1918 when adjustments were begun, first to make the rate of application of rock phosphate four times that of bone meal, and finally to reduce the amounts of these materials to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per annum. The usual practice has been to apply and plow under at one time all phosphorus and potassium required for the rotation.

Potassium (**K**) has been applied on Plots 8 and 9 in connection with the bone meal and rock phosphate, at the yearly rate of 42 pounds per acre, and mainly as potassium sulfate.

On Plot 10 about five times as much manure and phosphorus are applied as on the other plots, but this "extra heavy" treatment was not begun until 1906, only the usual amounts of lime, phosphorus, and potassium having been applied in previous years. The purpose in making these heavy applications is to try to determine the climatic possibilities in crop yields by removing the limitations of inadequate amounts of the elements of plant food.

It will be observed that the applications described above provide for the two rather distinct systems of farming already described. *The grain system,* in which animal manure is not produced and where the organic matter is provided by the direct return to the soil of crop residues along with legumes, is exemplified in Plots 2, 4, 6, and 8; and the *live-stock system,* in which farm manure is utilized for soil enrichment, is represented in the corresponding Plots 3, 5, 7, and 9.

Table 3 shows a summary of the results obtained on the Davenport plots beginning with the year 1911, when the present cropping system was introduced.

When used in conjunction with phosphorus the crop residues and the manure appear about equally effective; but where phosphorus is not applied manure has been decidedly more effective than residues in corn and wheat, under the conditions of the experiment. It should be observed, however, in this connection, that the plowing under of clover is a very essential feature of the residues system, and that, as a matter of fact during the thirteen years there were five clover failures, when soybeans were substituted. Perhaps with a more reliable biennial legume than red clover, the results would have been more favorable for this system.

By comparing Plots 2 and 3 with Plots 4 and 5, it is found that limestone has had a beneficial effect on all crops. What the financial profit amounts to de

TABLE 3.—URBANA FIELD, DAVENPORT PLOTS: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

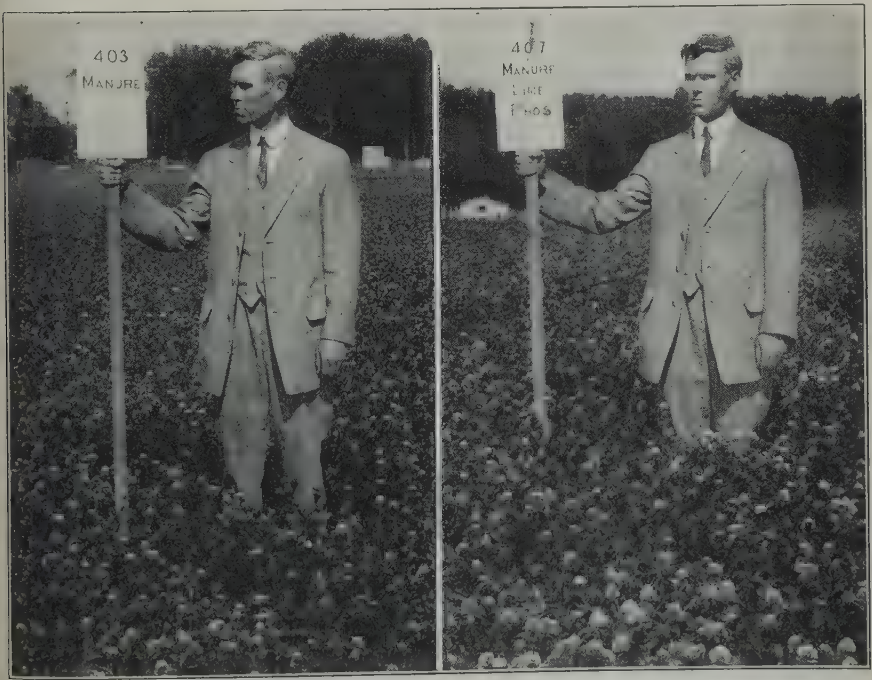
Average Annual Yields 1911-1923—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *13 crops*	Oats *13 crops*	Wheat *13 crops*	Clover or Soybeans: Clover[1] *8 crops*	Soybeans[2] *5 crops*	Alfalfa *13 crops*
1	0	54.3	52.3	25.8	(2.10)	(1.47)	(2.44)
2	R	55.1	53.6	28.5	1.38	19.8	(2.55)
3	M	65.5	64.4	28.9	(2.29)	(1.62)	(2.50)
4	RL	63.8	56.4	31.6	1.58	20.3	(2.76)
5	ML	69.3	64.8	34.2	(2.69)	(1.67)	(2.99)
6	RLP	70.6	69.7	42.0	1.72	23.5	(3.78)
7	MLP	71.6	69.2	40.9	(3.31)	(1.97)	(3.87)
8	RLPK	70.8	72.0	39.7	1.35	25.5	(3.97)
9	MLPK	69.6	71.5	40.0	(3.32)	(2.20)	(3.89)
10	Mx5LPx5	65.3	71.0	40.0	(2.85)	(2.22)	(3.94)

[1]In addition to the clover seed a crop of hay was taken from Plots 2, 4, 6, and 8 in the year 1918 and again in 1921, producing yields which, reduced to an eight-year average, amount to .40, .45, .50, and .50 tons respectively.
[2]Soybeans substituted when clover failed.

pends obviously upon the market value of the crops and the cost of the limestone.

Comparing Plots 4 and 5 with Plots 6 and 7, respectively, there is found in all cases an increase in crop yield as a result of adding phosphorus. The



Manure
Yield: 1.43 tons per acre

Manure, limestone, phosphorus
Yield: 2.90 tons per acre

FIG. 2.—CLOVER ON THE DAVENPORT PLOTS IN 1913

effect on wheat is especially pronounced. Where limestone and phosphorus are applied in addition to the crop residues, an increase of 16.2 bushels of wheat, over the yield of the untreated land, has been obtained as a thirteen-year average.

The effect of adding potassium to the treatment is of much interest. Plots 8 and 9 are similar to Plots 6 and 7, respectively, except that potassium has been applied to the former. The small gains appearing in certain cases are counterbalanced by losses in others so that on the whole potassium treatment has not been effective on these plots.

No benefit appears as the result of the extra-heavy applications of manure and phosphorus on Plot 10. In fact the corn and clover yields are noticeably less here than on the plots receiving the normal applications of these materials.

The University South Farm

On the University South Farm, at Urbana, several series of plots devoted primarily to variety testing and other crop-production experiments are so laid out as to show the effects of certain soil treatments that have been applied. Several different systems of crop rotation are employed and the crops are so handled as to exemplify the two general systems of farming, grain and live-stock.

The summarized results presented in Table 4 represent three different systems of cropping. The first, designated as the Southwest rotation, is to be re-

Residues plowed under
Yield: 35.2 bushels per acre

Residues and rock phosphate
Yield: 50.1 bushels per acre

FIG. 3.—WHEAT ON THE UNIVERSITY SOUTH FARM IN 1911

TABLE 4.—URBANA FIELD, SOUTH FARM: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields 1908-1919—Bushels or (tons) per acre

Southwest Rotation: Series 100, 200, 400[1]: Wheat, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn[3] 9 crops	Oats[3] 9 crops	Wheat[3] 8 crops	Clover[4] 3 crops	Soybeans 7 crops
RP	62.3	51.9	41.0	1.05	17.3[5]
R	51.9	46.5	26.9	1.38	16.2[5]
M	59.7	50.2	29.1	(2.28)	(1.25)
MP	64.3	55.4	43.1	(2.86)	(1.51)
RLP	60.5	57.2	41.8	.64	16.4[5]
R	49.7	49.6	25.8	.83	14.7[5]
M	55.5	54.1	27.8	(2.31)	(1.28)
MLP	64.1	59.6	43.9	(2.82)	(1.58)

North-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Oats 9 crops	Clover 5 crops	Soybeans 4 crops
RP	56.7	51.1	56.1	.54	16.9
R	51.7	45.2	52.0	.50	16.0
M	54.9	46.7	52.1	(2.29)	(1.60)
MP	56.5	53.4	56.9	(2.73)	(1.74)

South-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Corn, Soybeans

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Corn 3d year 9 crops		Soybeans 9 crops
RP	51.9	44.0	41.3		20.0
R	45.5	39.9	35.2		19.2
M	50.1	42.1	33.5		(1.59)
MP	54.5	46.7	42.0		(1.66)

[1]Results from Series 300 and 800 are omitted on account of variation in soil type.
[2]Soybeans when clover fails.
[3]Only seven crops with limestone.
[4]Only one crop with limestone.
[5]Average of five crops.
[6]All phosphorus plots received ½ ton per acre of limestone in 1903.

garded as a good rotation for general practice, on this type of soil, under Illinois conditions. This is a four-field rotation of wheat, corn, oats, and clover. The second, or North-Central rotation, consisting of corn, corn, oats, and clover, represents a system very commonly practiced; and the third or South-Central rotation, consisting of corn, corn, corn, and soybeans, must be considered as a poor rotation from the standpoint of maintaining the productiveness of the land.

On the whole, the "residues" have not returned as high yields as those produced by the manure treatment; but, as remarked above in the discussion of the Davenport plots, the residues system has probably been at a disadvantage thru frequent clover failures. On the North-Central rotation, where conditions seem to have been more favorable for clover, there is relatively little difference between the effect of manure and of residues.

Limestone, which has been used in the southwest rotation, appears to have produced no increase of consequence to any of the crops except oats. The com-

parison may be somewhat impaired, however, by a possible residual effect of the small application of limestone made in 1903 to all the phosphorus plots.

The results obtained from the use of phosphorus are of especial interest because this element has been applied on this field solely in the form of raw rock phosphate. The figures in almost every case show an increase in yield where the phosphate has been applied, and in most cases this increase is very pronounced. The wheat is especially responsive to phosphorus.

The records from this field furnish some interesting comparisons of corn yields produced under different systems of cropping. Table 5 gives a general summary of the corn yields only, in which the results from the residues and manure treatments are averaged together as "organic manures." The highest annual acre-yields are found where corn occurs but once in a rotation. Where corn is grown twice in succession, the annual acre-yields are less; and where corn occurs three times, there is a further reduction. Also, the first crop of corn within a rotation produces more than the second, and the second crop yields more than the third. These are useful facts for consideration in connection with problems of general farm management.

TABLE 5. COMPARING PRODUCTION OF CORN IN THREE DIFFERENT ROTATION SYSTEMS
ACRE YIELDS FROM PLOTS ON THE UNIVERSITY SOUTH FARM

Twelve-Year Average (1908-1919)—Bushels per acre

Rotation	Wheat-corn-oats-legume[1]	Corn-corn-oats-legume[2]		Corn-corn-corn-legume[3]		
Treatment	Corn	1st Corn	2d Corn	1st Corn	2d Corn	3d Corn
Organic manures	55.8	53.3	46.0	47.8	41.0	34.3
Organic manures, phosphorus	63.2	56.6	52.3	53.2	45.3	41.6

[1]Clover 3 crops, and soybeans 7 crops.
[2]Clover 5 crops, and soybeans 5 crops.
[3]Soybeans 9 crops.

The Carthage Field

An experiment field on Brown Silt Loam is located in Hancock county just south of Carthage. This field has been in operation since 1911. The diagram presented as Fig. 4 shows the arrangement of plots on the Carthage field. There are two systems of plots representing two separate crop rotations designated as the major and minor rotations. The first system comprizes four series (numbered 100-200-300-400) made up of 10 plots each, and the rotation is wheat, corn, oats, and clover. The yields of all crops grown in this rotation each year since the beginning of the experiments are recorded in Table 6. The results are summarized in Table 7 where the average annual yields are shown for each plot covering the years that full treatment has been in effect. For the present purpose only the grain crops are considered in this summary. The lower section of this table gives a more condensed summary which affords some interesting comparisons. Here the results from the corresponding plots of the live-stock and the grain system are so combined as to bring out the effect of organic manures alone, organic manures in combination with limestone, and organic manures in combination with limestone and phosphorus.

In looking over these results, attention is first called to the beneficial effect of organic manures, whether applied in the form of animal manure or plant

manures (crop residues and legumes turned under). This suggests the importance of carefully conserving and regularly applying all available stable manure. If stable manure is not available in sufficient quantity, then, as these results demonstrate, the necessary organic matter can be supplied by returning to the land all unused crop residues and plowing under legumes as green manure.

The results also bring out the beneficial effect of limestone on this soil, all crops showing in the general averages an increase in yield where limestone has been applied.

Taking into account the variations exhibited by the untreated check plots, it seems doubtful whether the small gains appearing as the effect of rock phosphate as used on this field are really significant. At any rate the small gains thus far secured would not be sufficient to cover the cost of the material.

For the effect of the potassium treatment we may compare Plots 8 and 9. Here again there has been no significant response to the treatment unless it be in the case of the wheat crop, where the averages show an increase of 3 bushels per acre for Plot 9 over Plot 8. From the standpoint of economic practice, however, this increase would scarcely justify a recommendation for the general use of potassium in this system of farming.

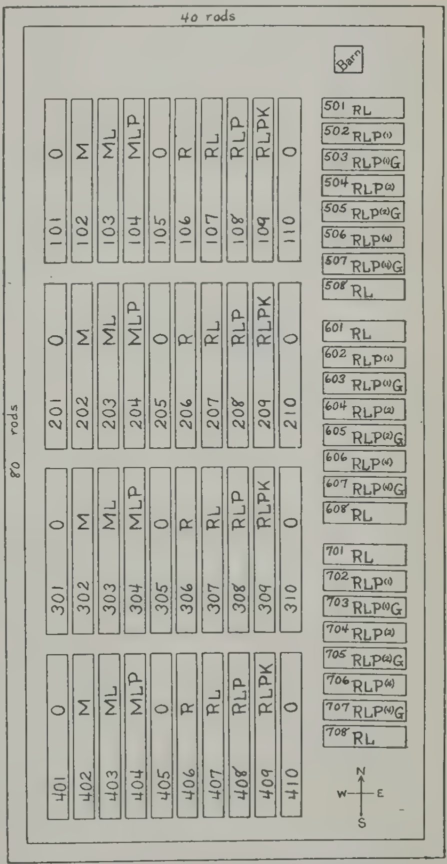


FIG. 4.—DIAGRAM OF CARTHAGE EXPERIMENT FIELD

The minor rotation (series 500-600-700) on the Carthage field is given over to an experiment to determine the effects of different amounts of rock phosphate applied with and without gypsum. This work has scarcely been under way long enough to warrant conclusions and, as a matter of fact, very little effect of the treatments are to be seen as yet. However, since the field is located in Hancock county and should, therefore, be of especial interest in this report, it is the purpose to place on record here all the results on the Carthage field to date. The data for this minor rotation together with a description of the treatments and the arrangement of the plots are shown in Table 8. About the only noticeable effect of the treatments to be observed is a rather consistent tendency toward a depression on the gypsum plots in the year 1923. Judgment, however, must be withheld for the accumulation of further data.

TABLE 6.—CARTHAGE FIELD: BROWN SILT LOAM, PRAIRIE; UPPER ILLINOISAN GLACIATION
ROTATION: WHEAT, CORN, OATS, CLOVER

Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1911 Corn[1]	1912 Oats[2]	1913 Clover[5]	1914 Wheat[6]	1915 Corn	1916 Oats	1917 Clover	1918 Wheat	1919 Corn	1920 Oats	1921 Clover	1922 Wheat	1923 Corn
101	0..........	39.4	31.4	(2.46)	18.8	35.9	20.3	(2.68)	17.1	34.4	33.3	(1.12)	20.7	41.9
102	M..........	43.7	33.9	(2.64)	19.2	43.0	31.2	(2.53)	28.6	42.3	36.6	(1.33)	22.1	64.7
103	ML........	38.5	33.3	(3.06)	22.9	40.0	32.8	(2.37)	37.6	51.6	42.0	(1.95)	26.6	75.4
104	MLP.......	41.0	37.0	(3.02)	23.6	47.0	35.9	(2.54)	42.0	63.7	48.1	(2.17)	27.7	74.6
105	0..........	35.0	30.2	.67	25.6	23.1	23.4	.67	31.8	40.5	35.2	1.33	18.5	52.4
106	R..........	30.7	24.4	.67	24.7	23.4	25.0	.67	35.2	51.4	28.9	1.55	22.0	60.7
107	RL........	31.6	26.1	.50	25.0	37.0	29.7	.58	39.1	59.5	46.4	2.41	26.8	69.0
108	RLP.......	31.2	26.3	.50	27.7	45.0	34.4	1.08	44.8	61.1	43.8	2.42	28.2	69.9
109	RLPK.....	32.0	26.1	.50	28.3	47.6	40.6	.92	45.9	57.9	44.5	2.39	28.7	73.0
110	0..........	36.5	31.4	(3.64)	28.4	24.2	21.9	(2.00)	31.6	42.9	32.8	1.45	20.1	53.1
		Wheat[7]	Corn[3]	Oats	Clover	Wheat	Corn	Oats	Clover	Wheat	Corn	Oats	Soybeans	Wheat
201	0..........	4.3	33.3	27.2	(1.14)	24.0	23.5	49.7	(2.60)	31.9	36.9	28.1	18.8	14.8
202	M..........	4.9	38.8	30.0	(1.25)	26.7	27.9	51.7	(2.42)	30.8	40.6	35.2	18.3	21.2
203	ML........	3.8	39.7	32.0	(1.52)	28.7	32.9	57.8	(2.45)	30.8	48.3	45.8	19.8	28.6
204	MLP.......	4.7	40.8	33.9	(1.66)	30.1	29.1	66.9	(2.16)	30.8	51.2	48.3	15.8	30.8
205	0..........	4.5	30.4	26.7	1.42	24.0	23.2	56.4	.17	31.8	43.7	32.0	14.2	17.6
206	R..........	4.4	42.3	22.5	1.42	30.8	23.4	67.0	.17	25.1	43.7	37.5	19.8	20.8
207	RL........	5.0	41.3	24.4	1.33	34.2	29.9	72.0	.50	23.5	57.3	43.8	8.7	34.8
208	RLP.......	5.4	55.4	27.5	1.50	38.0	27.6	66.1	1.83	24.5	49.3	45.3	8.8	34.7
209	RLPK.....	5.3	57.2	26.9	1.08	38.8	31.7	64.1	1.33	25.5	52.0	40.2	11.8	35.5
210	0..........	4.5	28.2	25.0	(1.88)	31.2	20.6	40.9	(2.41)	21.2	38.9	27.3	21.4	20.5

TABLE 6.—CARTHAGE FIELD: *Concluded*

Plot No.	Soil treatment applied	1911 Soybeans[1]	1912 Wheat[4]	1913 Corn	1914 Oats	1915 Soybeans	1916 Wheat	1917 Corn	1918 Oats	1919 Soybeans	1920 Wheat	1921 Corn	1922 Oats	1923 Soybeans
301	0..........	11.0	7.4	25.3	18.0	(2.40)	7.2	22.1	37.3	(1.78)	30.6	39.9	37.8	31.2
302	M..........	10.3	3.6	26.1	15.6	(2.90)	12.5	26.5	38.8	(1.97)	32.3	39.3	45.2	27.1
303	ML........	9.3	3.8	23.7	17.2	(2.99)	16.7	36.2	35.9	(1.68)	39.3	54.6	51.1	30.4
304	MLP.......	11.3	5.3	34.8	17.0	(3.11)	22.5	41.4	35.3	(1.66)	41.1	57.6	53.8	28.8
305	0..........	10.8	5.7	28.6	17.8	19.2	7.5	17.4	30.3	16.6	18.4	19.4	35.9	23.6
306	R..........	10.8	4.3	47.8	23.4	21.7	8.3	54.2	43.0	19.5	18.7	49.4	46.1	24.3
307	RL........	11.5	6.8	49.7	26.6	23.3	18.8	61.9	49.4	22.2	36.8	54.5	57.0	29.7
308	RLP.......	10.3	5.5	49.1	23.6	29.7	20.0	67.8	69.7	21.5	32.1	53.6	53.9	28.2
309	RLPK	10.7	7.1	51.3	24.2	26.7	25.0	66.1	53.8	22.8	41.6	57.9	54.4	29.2
310	0..........	10.2	6.5	29.2	19.2	(2.39)	10.8	37.0	32.2	(1.59)	27.3	35.5	40.0	22.8
		Oats[1]	Soybeans[2]	Wheat[4]	Corn	Oats	Clover	Wheat	Corn	Oats	Clover	Wheat	Corn	Oats
401	0..........	12.7	20.6	24.0	24.6	30.6	(2.23)	18.8	32.4	37.8	(2.37)	24.8	58.1	45.3
402	M..........	10.6	17.9	29.8	39.5	37.8	(1.88)	19.2	38.4	38.0	(2.47)	33.8	65.9	52.7
403	ML........	14.8	19.6	29.1	40.8	48.4	(2.18)	18.9	52.8	41.2	(2.73)	34.5	71.3	60.2
404	MLP.......	15.5	20.4	24.2	44.7	49.7	(2.72)	17.5	53.5	45.3	(2.69)	33.8	76.9	59.7
405	0..........	12.8	16.9	21.0	26.4	30.3	.08	16.7	34.7	40.2	(1.51) 2.32	24.3	57.5	41.3
406	R..........	9.8	15.0	16.4	35.4	35.9	.17	18.9	36.0	43.6	(1.73) 1.98	20.3	64.2	38.0
407	RL........	13.3	14.6	24.2	47.2	54.7	.08	21.7	33.3	40.0	(1.21) 2.02	31.5	79.9	51.3
408	RLP.......	10.3	16.5	23.2	57.2	60.3	.17	15.2	47.3	45.3	(1.89) 2.05	35.3	78.4	55.8
409	RLPK	11.3	16.3	23.2	58.3	59.4	.50	24.1	44.9	46.6	(1.71) 1.82	34.8	82.2	63.8
410	0..........	10.9	17.0	22.7	31.3	28.1	(2.44)	16.0	37.3	37.7	(2.80)	23.8	62.5	39.5

[1]No soil treatment. [2]Residues only. [3]No lime. [4]No manure or lime. [5]No manure, phosphate, or potassium. [6]No manure. [7]Phosphorus and potassium only.

TABLE 7.—CARTHAGE FIELD: GENERAL SUMMARY OF THE GRAIN CROPS
Average Annual Yields, 1913-1923—Bushels per acre

Serial plot No.	Soil treatment applied	Wheat *9 crops*	Corn *11 crops*	Oats *11 crops*
1	0	21.1	34.1	33.2
2	M	25.2	41.3	37.5
3	ML	29.1	48.0	42.2
4	MLP	30.6	52.2	44.9
5	0	21.2	33.4	33.6
6	R	22.2	44.5	37.4
7	RL	29.7	52.7	45.0
8	RLP	30.3	55.1	47.8
9	RLPK	33.3	56.6	47.1
10	0	22.5	37.5	31.3
1 5 10	0 0 0	21.6	35.0	32.7
2 6	M R	23.7	42.9	37.5
3 7	ML RL	29.4	50.4	43.6
4 8	MLP RLP	30.5	53.7	46.4

TABLE 8.—CARTHAGE FIELD: ROCK PHOSPHATE AND GYPSUM EXPERIMENT
ROTATION: CORN, CORN, OATS (WITH SWEET CLOVER)

Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1920 Corn	1921 Oats	1922 Corn		1923 Corn	
501	RL	31.8	23.8	68.0		70.0	
502	RL + 100 lbs. Rock phos	51.8	29.8	71.4		74.8	
503	RL + 100 lbs. Rock phos. + 100 lbs. Gypsum	48.6	29.4	72.0		71.6	
504	RL + 200 lbs. Rock phos	61.2	29.7	74.8		75.8	
505	RL + 200 lbs. Rock phos. + 200 lbs. Gypsum	60.6	31.2	72.6		70.6	
506	RL + 400 lbs. Rock phos	68.0	30.9	74.4		89.0	
507	RL + 400 lbs. Rock phos. + 400 lbs. Gypsum	66.8	32.5	73.6		61.2	
508	RL	67.0	32.2	72.4		76.8	
		Corn	Corn	Oats	Clover	Corn	
601	RL	68.4	60.6	43.8	(.93)	76.4	
602	RL + 100 lbs. Rock phos	68.6	73.8	40.3	(1.08)	74.2	
603	RL + 100 lbs. Rock phos. + 100 lbs. Gypsum	63.6	58.2	43.8	(1.30)	71.6	
604	RL + 200 lbs. Rock phos	63.6	67.8	43.4	(1.10)	75.4	
605	RL + 200 lbs. Rock phos. + 200 lbs. Gypsum	62.4	72.0	40.6	(1.00)	70.8	
606	RL + 400 lbs. Rock phos	58.4	67.0	44.7	(1.08)	72.2	
607	RL + 400 lbs. Rock phos. + 400 lbs. Gypsum	68.6	71.4	43.4	(.98)	68.8	
608	RL	70.8	64.2	44.1	(.98)	72.6	
		Oats	Corn	Corn		Oats	Clover
701	RL	45.6	61.8	53.4		50.6	(1.39)
702	RL + 100 lbs. Rock phos	31.2	71.0	52.6		53.2	(1.25)
703	RL + 100 lbs. Rock phos. + 100 lbs. Gypsum	61.6	64.6	58.8		51.9	(1.31)
704	RL + 200 lbs. Rock phos	39.7	62.4	50.2		46.3	(1.27)
705	RL + 200 lbs. Rock phos. + 200 lbs. Gypsum	48.1	60.8	54.4		38.1	(1.07)
706	RL + 400 lbs. Rock phos	40.3	61.6	63.4		44.1	(1.30)
707	RL + 400 lbs. Rock phos. + 400 lbs. Gypsum	42.5	57.2	57.4		45.9	(1.22)
708	RL	38.8	59.6	60.0		47.5	(1.40)

The Clayton Field

Another experiment field representing Brown Silt Loam is located in Adams county just south of Clayton. This field has been under way since 1911. The crop rotation consists of wheat, corn, oats, and clover. Soybeans have been substituted several times for the clover when the latter failed. Table 9 shows a summary of the results in the form of the average annual yields of the respective grain crops.

TABLE 9.—CLAYTON FIELD: BROWN SILT LOAM, PRAIRIE; UPPER ILLINOISAN GLACIATION
Average Annual Yields of Grain Crops, 1913-1923—Bushels per acre

Serial plot No.	Soil treatment applied	Wheat *9 crops*	Corn *11 crops*	Oats *11 crops*
1	0	17.4	31.2	36.1
2	M	21.6	47.5	43.7
3	ML	23.6	53.2	44.4
4	MLP	26.7	52.4	46.5
5	0	17.1	33.4	38.0
6	R	20.8	45.1	40.5
7	RL	23.5	53.6	48.5
8	RLP	27.3	53.8	51.5
9	RLPK	27.5	58.2	51.6
10	0	18.3	35.0	40.4
1 5 10	0 0 0	17.6	33.2	38.2
2 6	M R	21.4	46.3	42.1
3 7	ML RL	23.6	53.4	46.5
4 8	MLP RLP	27.0	53.1	49.0

Combining the results of the corresponding plots of the grain system and the live-stock systems as shown in the lower section of Table 9, we have some interesting comparisons. The beneficial effect of organic manures is very apparent whether they are applied in the form of animal manure or of plant manures. All crops likewise show an increase for limestone applied with the organic manures. The use of rock phosphate applied with organic manures and limestone has produced still further increase for wheat, but not for corn, and the effect on the oats is doubtful in view of the wide variation in check plots. Potassium salts appear to have benefited the corn, but not the wheat and oats, altho the increase in corn yield would not pay for the cost of the treatment.

The Bloomington Field

The experiments on the Bloomington field are of interest in connection with the management of Brown Silt Loam. This field is located in McLean county, northeast of the city of Bloomington. The work was started in 1902. Altho a fairly long period of years has been covered in these experiments, the field has

only a single series of plots so that only one kind of crop is represented each season. The crops employed have been corn, corn, oats, clover, and wheat, and, since 1905, they have been grown in the sequence named.

On account of irregularities in the land, results from Plots 1 and 10 are not considered altogether reliable; therefore, they are not included in the figures presented. Since these are the only unlimed plots no conclusions can be drawn regarding the action of limestone on this field.

Commercial nitrogen applied in the form of dried blood was used in the early years up to 1905, when crop residues and clover were substituted. The phosphorus on this field has always been applied in the form of steamed bone meal and at the rate of 200 pounds per acre per year.

Table 10 presents a summary of the work by annual average yields for the corn, oats, and wheat crops. The comparisons in the lower part of the table show the effect of the different plant-food materials in the various combinations in which they have been applied.

As might be expected the "residues" treatment, supplying organic matter and nitrogen, shows a beneficial effect. It is of interest to note that the effect of the residues is greater on the phosphorus plots than on those not receiving phosphorus.

The outstanding feature of the results on the Bloomington field is the effect of phosphorus, as applied in the form of bone meal. In every crop on every plot where bone meal has been applied there is a remarkable response to the

TABLE 10.—BLOOMINGTON FIELD: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields of Grain Crops, 1902-1923—Bushels per acre

Serial plot No.	Soil treatment applied	Corn *10 crops*	Oats *4 crops*	Wheat *4 crops*
2	L	41.5	44.7	24.1
3	LR	47.5	46.2	27.9
4	LP	55.8	54.3	45.7
5	LK	46.2	43.5	25.5
6	LRP	60.6	66.0	49.7
7	LRK	48.6	46.8	27.5
8	LPK	60.9	57.2	44.5
9	LRPK	64.2	63.1	50.4
	Increases—Bushels per acre			
	For Residues			
	LR over L	6.0	1.5	3.8
	LRP " LP	4.8	11.7	4.0
	LRK " LK	2.4	3.3	2.0
	LRPK " LPK	3.3	5.9	5.9
	For Phosphorus			
	LP over L	14.3	9.6	21.6
	LRP " LR	13.1	19.8	21.8
	LPK " LK	14.7	13.7	19.0
	LRPK " LRK	15.6	16.3	22.9
	For Potassium			
	LK over L	4.7	−1.2	1.4
	LRK " LR	1.1	.6	−.4
	LPK " LP	5.1	2.9	−1.2
	LRPK " LRP	3.6	−2.9	.7

treatment as shown by the increases in yield. This response appears in all the combinations, even without the presence of residues, altho in combination with either residues or potassium the effect is accentuated. For example, comparing Plot 3 with Plot 6 (limestone and residues, with limestone, residues and phosphorus) we find the phosphorus treatment has produced an average increase in the yield of corn of about 13 bushels per acre, while the yield of oats has been increased by about 20 bushels and that of wheat by about 22 bushels per acre. Similar increases, tho not so pronounced, appear in comparing Plot 5 with Plot 8 where potassium instead of residues is present.

Thus it appears that on this field, under this system of farming, the lack of phosphorus is distinctly a limiting factor in production and the application of this element in the form of steamed bone meal is attended by a high financial profit. It is of extreme interest to know whether a similar response would follow the use of other phosphorus carriers such as rock phosphate and acid phosphate and experiments are now under way designed to answer this question.

Quite different are the results from the use of potassium on this field. The potassium has been applied mainly in the form of potassium sulfate, but in 1917, when this material became unavailable thru war conditions, potassium carbonate was substituted. There is a moderate increase in the corn yield where potassium has been used and particularly where residues are absent. Otherwise, the small gains shown on some plots are offset by losses on other plots, but these small differences are probably well within the limits of experimental error.

YELLOW-GRAY SILT LOAM

The type Yellow-Gray Silt Loam exhibits an important variation with respect to limestone content. In some areas, altho limestone may be altogether absent in the surface stratum it is found in abundance at a short distance beneath the surface. Accordingly, variations in response to soil treatment are exhibited by different experiment fields located on this type. In view of this variation it is thought well to introduce here the records of two fields, that are representative of the type but which show a marked diversity in results, one in northern Illinois and one in the southern part of the state.

The Antioch field is located on the late Wisconsin glaciation, in Lake county, close to the Wisconsin border. The field was started in 1902, with but a single series of ten plots, under a rotation of corn, corn, oats, and wheat; but beginning with 1911 the rotation has been wheat, corn, oats, and clover. Nitrogen was supplied in the earlier years in 800 pounds of dried blood per acre but after 1911 the use of commercial nitrogen was discontinued and crop residues were substituted. Phosphorus is applied in 200 pounds of steamed bone meal, and potassium in 100 pounds of potassium sulfate. At the beginning, 470 pounds of slaked lime was applied; and since 1912 limestone has been applied at the rate of 1,000 pounds per acre per year.

Table 11 presents, in summarized form, the results of the grain crops from the Antioch field. Because of an abnormality in Plot 1, the results from this plot are not considered. The data show that phosphorus is the one element standing out prominently as producing consistently beneficial results. Potassium applied in addition to phosphorus has been, on the whole, ineffective. Also, the

Lime applied and residues plowed under — Lime and phosphorus applied

FIG. 5.—CLOVER IN 1913 ON ANTIOCH FIELD

results are unfavorable for the application of limestone. Limestone, however, is abundant in the subsoil of this type in the region of this field.

The Raleigh experiment field is located on the lower Illinoisan glaciation, in southern Illinois, in Saline county. This field is laid out into four series of ten plots each, under a rotation of wheat, corn, oats, and clover. The treatments, along with the summarized results, are given in Table 12.

The outstanding feature of these results is the effect of limestone. Altho manure alone produces a substantial increase, especially in the corn crop, when

TABLE 11.—ANTIOCH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LATE WISCONSIN GLACIATION

Average Annual Yields of Grain Crops, 1902-1923—Bushels or (tons) per acre

Plot No.	Soil treatment applied	Corn *9 crops*	Oats *5 crops*	Wheat *5 crops*
1	0	24.5	32.3	14.7
2	L	21.8	26.8	13.3
3	LR	22.5	29.9	18.9
4	LP	31.0	43.6	35.0
5	LK	23.3	27.8	17.8
6	LRP	34.1	43.3	32.6
7	LRK	25.4	26.9	19.2
8	LPK	26.1	38.2	30.3
9	LRPK	38.9	42.6	28.1
10	RPK	38.7	44.7	31.0

TABLE 12.—RALEIGH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LOWER ILLINOISAN GLACIATION

Average Annual Yields of Grain Crops, 1911-1923
Bushels or (tons) per acre

Plot No.	Soil treatment applied	Corn *13 crops*	Oats *13 crops*	Wheat *9 crops*
1	0	16.6	9.6	5.7
2	M	29.7	11.8	7.2
3	ML	43.3	19.6	18.9
4	MLP	44.1	20.0	19.9
5	0	17.7	9.5	6.4
6	R	20.9	11.8	8.0
7	RL	36.8	21.1	17.9
8	RLP	39.4	22.4	19.7
9	RLPK	45.8	22.8	22.2
10	0	20.5	10.8	5.9

limestone is added a remarkable increase is found in all crops. A most important fact is that the organic matter can be effectively built up thru the use of crop residues, with the application of limestone, so that the crop yields are practically as high under this "grain system" of farming as where manure is used.

Phosphorus is applied here in the form of rock phosphate, which thus far has given only moderate returns in increased crop yields.

Potassium as applied with residues, lime, and phosphorus seems to be of some benefit for both corn and wheat.

Manure, limestone, phosphorus
Yield: 61 bushels per acre

Nothing applied
Yield: 15 bushels per acre

FIG. 6.—CORN ON RALEIGH FIELD IN 1920

In accounting for the difference in the response to limestone on these two fields, the fact is to be considered that the Antioch field is located on the late Wisconsin glaciation, where the subsoil contains large quantities of limestone; while the Raleigh field represents the lower Illinoisan glaciation, the soil of which is very acid to a great depth. In view of these variations, a general recommendation for lime treatment, that will apply to all localities on Yellow-Gray Silt Loam cannot be given out until more information is acquired. Fortunately, however, each farmer can determine for himself the need of limestone for his land by applying the simple tests for the presence of carbonates and soil acidity, as explained under the discussion of limestone on pages 32 and 33 of the Appendix.

Phosphorus, as applied in bone meal, has paid well on the Antioch field, but, as applied in rock phosphate on the Raleigh field, has failed thus far to return the cost of the material. This must not be construed as a comparison between bone meal and rock phosphate as carriers of phosphorus, for these results do not furnish such a comparison. With the information at hand no definite recommendation concerning the application of phosphorus that will apply to this soil type as a whole can be given at present. It is suggested, however, that each farmer might well try out phosphorus on his own land on a limited scale, and be guided by the outcome of his experience. The low phosphorus content of the surface stratum of this soil is an indication that in a system of permanent agriculture the time may not be far off when phosphorus will become a limiting element to crop production, and the wise farmer will watch carefully the indications and be ready to make timely provision for this need.

YELLOW SILT LOAM

Because such a large proportion of the area of Hancock county is made up of Yellow Silt Loam it is believed that on account of some experiments on the Vienna field, the single representative of this type of soil, will be of interest here.

FIG. 7.—VIEW OF UNIMPROVED HILLSIDE LAND TAKEN JUST OVER THE FENCE FROM THE FIELD SHOWN IN FIG. 8

The Vienna Field

In 1906 the University acquired a sixteen-acre tract of land representative of Yellow Silt Loam near Vienna in Johnson county. The whole area with the exception of about three acres had been abandoned because so much of the surface soil had washed away and there were so many gullies as to render further cultivation of this land unprofitable. Experiments were started at once to reclaim this land, the different methods described below being used for this purpose.

The field was divided into five sections. The sections designated as A, B, and C were divided into four plots each, and D into three plots. On section A, which included the steepest part of the area and contained many gullies, the land was built up into terraces at vertical intervals of five feet. Near the edge of each terrace a small ditch was placed so that the water could be carried to a natural outlet without doing much washing.

On section B the so-called embankment method was used. By this method erosion is prevented by plowing up ridges sufficiently high so that on the occasion of a heavy rainfall if the water breaks over it will run over in a broad sheet rather than in narrow channels. At the steepest part of the slope, hillside ditches were made for carrying away the run-off.

Section C was washed badly but contained only small gullies. Here the attempt was made to prevent washing by incorporating organic matter in the soil and practicing deep contour plowing and contour planting. With two exceptions, about eight loads of manure per acre were turned under each year for the corn crop.

The land on section D was washed to about the same extent as that of section C. As a check on the different methods of reducing erosion, the land on section D was farmed in the most convenient way, without any special effort being made to prevent washing.

Section E was badly eroded and gullied and no attempt was made to crop it other than to fill in the gullies with brush and to seed the land to grass.

FIG. 8.—CORN CROP ON THE VIENNA EXPERIMENT FIELD GROWING ON IMPROVED HILLSIDE LAND THAT HAD BEEN FORMERLY BADLY ERODED. COMPARE WITH FIG. 7

Sections A, B, C, and D were not entirely uniform; some parts were washed more than others and portions of the lower-lying land had been affected by soil material washed down from above. When the field was secured, the higher land had a very low producing capacity. On many spots little or nothing would grow.

Limestone was applied to the entire field at the rate of 2 tons per acre. Corn, cowpeas, wheat, and clover were grown in a four-year rotation on each section except D which had but three plots.

Table 13 contains a summarized statement of the results obtained.

TABLE 13.—VIENNA FIELD: HANDLING HILLSIDE LAND TO PREVENT EROSION
Average Annual Yields, 1907-1915—Bushels or (tons) per acre

Section	Method	Corn *7 crops*	Wheat *7 crops*	Clover *3 crops*
A	Terrace	31.4	9.0	(0.68)
B	Embankments and hillside ditches	32.4	12.7	(0.97)
C	Organic matter, deep contour plowing, and contour planting	27.9	11.7	(0.80)
D	Check	14.1	4.6	(0.21)

These results indicate something of the possibilities in improving hillside land by protecting it from erosion. The average yield of corn from the protected series (A, B, and C) was 30.6 bushels per acre, as against 14.1 bushels for series D; wheat yielded 11.1 bushels in comparison with 4.6 bushels; and clover .82 ton in comparison with .21 ton.

A comparison of Figs. 7 and 8 will serve to indicate the possibility of improving this type of soil.

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 28

MASON COUNTY SOILS

By R. S. SMITH, E. E. DE TURK, F. C. BAUER, AND L. H. SMITH

URBANA, ILLINOIS, JUNE, 1924

The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or land owner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and land owner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due the late Professor J. G. Mosier, under whose direction the soil survey of Mason county was conducted, and to Mr. A. F. Gustafson, now Extension Professor of Soil Technology at Cornell University, who was in direct charge of the field party in the construction of the map.

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MASON COUNTY SOILS

APPENDIX

SUPPLEMENT

MASON COUNTY SOILS

By R. S. SMITH, E. E. DE TURK, F. C. BAUER, AND L. H. SMITH[1]

LOCATION AND CLIMATE OF MASON COUNTY

Mason county is located just west of the central part of the state. It is a medium-sized county, embracing 554 square miles, 494 square miles of which consist of a glacial terrace formation.

The climate of Mason county is typical of the region. It is characterized by a wide range between the extremes of winter and summer and by an abundant, well-distributed rainfall. The greatest range in temperature for any one year from 1904 to 1923 was 128 degrees in 1914. The lowest temperature recorded was –26° in 1905 and 1914; the highest, 106° in 1911 and 1918. The average date of the last killing frost in the spring is April 22; the earliest in the fall, October 19. The average length of the growing season is 180 days.

The average annual rainfall as recorded at Havana from 1904 to 1923 was 32.92 inches. The average rainfall by months for this period was as follows: January, 2.13 inches; February, 1.50; March, 2.37; April, 3.68; May, 4.07; June, 3.37; July, 3.22; August, 2.86; September, 4.08; October, 2.02; November, 2.03; December, 1.47.

AGRICULTURAL PRODUCTION

Mason county is distinctly agricultural, but only about 60 square miles of the 554 making up the county is typical of the corn belt. Something over 20 percent of the area of the county is so sandy as to be of lower agricultural value than the soils commonly occurring in the corn belt. According to the Fourteenth Census of the United States, there were 1,558 farms in 1920. The average acreage per farm was 199.9, 172.7 acres of which were improved. The number of farms has decreased at the rate of about 100 every ten years for the last two decades. This rate of decrease is exceeded by many counties in the state. Of these 1,558 farms, 60.5 percent were operated by tenants in 1920, which is a slight decrease in tenantry in the last twenty years.

The principal crops are corn, oats, wheat, rye, and forage crops, including timothy, mixed clover and timothy, clover, alfalfa, silage crops, and corn cut for forage. The following table shows the acreage and yield of the more important crops for the year 1919, as given by the above mentioned census.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn	82,731	2,680,066 bu.	32.4 bu.
Oats	24,771	552,279 bu.	22.3 bu.
Wheat	83,226	1,425,949 bu.	17.1 bu.
Rye	18,827	191,372 bu.	10.2 bu.
Timothy	1,884	2,301 tons	1.22 tons
Timothy and clover mixed	2,359	3,069 tons	1.30 tons
Clover	1,040	1,205 tons	1.16 tons
Alfalfa	1,724	4,160 tons	2.41 tons
Silage crops	745	3,887 tons	5.22 tons
Corn for forage	1,695	2,911 tons	1.72 tons

[1] R. S. Smith, in charge of soil survey mapping; E. E. DeTurk, in charge of soil analysis; F. C. Bauer, in charge of experiment fields; L. H. Smith, in charge of publications.

Mason county is not an important live-stock county. The total value of all live stock and live-stock products in 1919 was $3,408,320. The following figures taken from the 1920 Census show the character of the live-stock interests in Mason county.

Animals and Animal Products	*Number*	*Value*
Horses	9,518	$1,036,751
Mules	2,139	293,862
Beef Cattle	4,445	288,979
Dairy cattle	8,553	544,597
Swine	26,872	498,802
Poultry	162,971	158,221
Eggs and chickens	———	353,147
Dairy products	———	225,875

Fruit and vegetable growing are of very little importance in this county so far as commercial production is concerned.

SOIL FORMATION

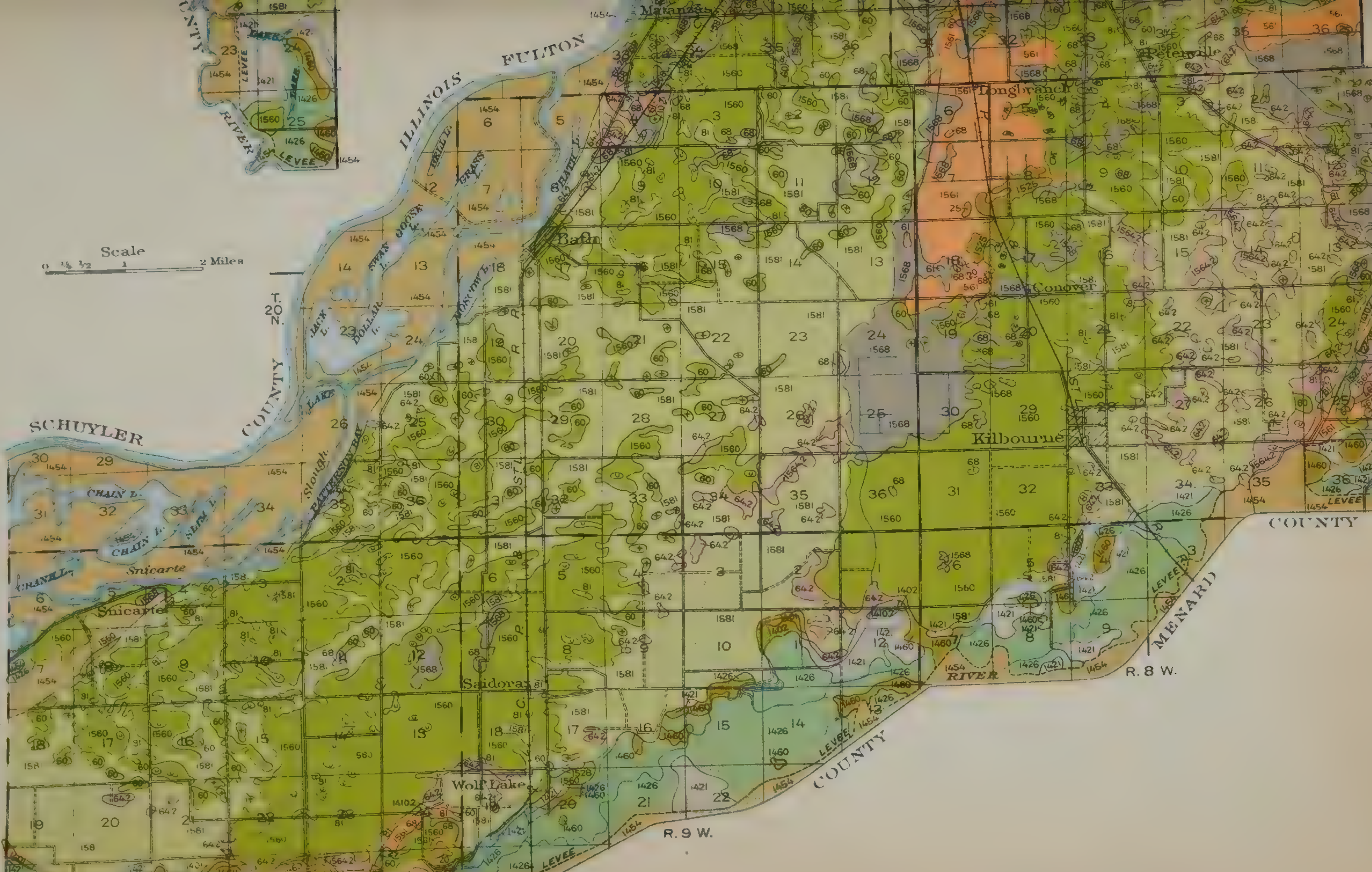
One of the most important periods in the geological history of the county, from the standpoint of soil formation, was the Glacial period, during which the material that later formed the soils was being deposited. At that time, snow and ice accumulated in the region of Labrador, west of Hudson Bay, and in the Rocky Mountains in great masses. These masses pushed outward from their centers, especially southward, until a point was reached where the ice melted as rapidly as it advanced. As the ice advanced, it buried everything, even the highest mountains, in its path. It would then recede slowly, and apparently normal conditions would be restored for a long period, after which another advance would occur. At least six of these great ice movements took place, each of which covered part of northern United States, altho the same parts were not covered during each advance.

In advancing from the distant northern centers of accumulation, the ice gathered up all sorts and sizes of material, including clay, silt, sand, gravel, boulders, and even large masses of rock. Some of these materials were carried several hundred miles, and the coarser masses rubbed against the surface rocks or against each other until largely ground into rock powder, which now constitutes much of the soil material in Illinois.

A pressure of forty pounds per square inch is exerted by a mass of ice one hundred feet thick, and these ice sheets may have been hundreds or even thousands of feet in thickness. The materials carried along in the ice, especially the boulders and pebbles, became powerful agents for grinding and wearing away the surface over which the ice passed. Preglacial ridges and hills were rubbed down, valleys were filled with the debris, and the surface features were entirely changed. The mixture of materials deposited by the glacier is known as boulder clay, till, glacial drift, or simply drift.

When, thru the melting of the ice, the limit of advance was reached, the material carried by the glacier was dropped along the front or side of the ice sheet and accumulated in a broad, undulating ridge or moraine, called a lateral moraine if formed at the side of the glacier and a terminal moraine if formed at the end. If the ice melted more rapidly than the glacier advanced, the


LEGEND
200 Illinoisan moraines
400 Middle Illinoisan intermorainal areas
800 Deep loess areas
UPLAND PRAIRIE SOILS
H 60 Brown sandy loam
26 Brown silt loam
826 Brown silt loam
27 427 Brown silt loam over sand
28 Brown-gray silt loam on tight clay
251 425 Black silt loam on clay
20 420 Black clay loam
81 Dune sand
486 Fine dune sand
90 Gravelly loam
UPLAND TIMBER SOILS
45 845 Yellow fine sandy silt loam
44 844 Yellow-gray fine sandy silt loam
65 Yellow sandy loam
64 464 Yellow-gray sandy loam
34 434 Yellow-gray silt loam
TERRACE SOILS
60 1560 Brown sandy loam
81 1581 Dune sand
61 1561 Black sandy loam
68 1568 Brown-gray sandy loam on tight clay
20 1520 Black clay loam
25 1525 Black silt loam
27 1527 Brown silt loam over sand or gravel
642 15642 Yellow-gray sandy loam on sand
28 1528 Brown-gray silt loam on tight clay
86 1586 Fine dune sand
1534 Yellow-gray silt loam
SWAMP AND BOTTOM LAND SOILS
1426 Deep brown silt loam
1454 Mixed loam
1421 Drab clay loam
01 1401 Deep peat
1402 Medium peat on clay
1410.2 Peaty loam on sand
13 1413 Clayey muck
1476 Yellow fine sandy loam
1460 Brown sandy loam
1480 Alluvial sand
ILLINOIS
SCHUYLER
RIVER
COUNTY
STEWART LAKE
CRANE LAKE
Hickory Slough
CASS
SANGAMON
R. 11 W.
T. 23 N.
T. 22 N.
T. 21 N.
MUD L.
LIVERPOOL LAKE
GOOSE LAKE
DENNIS L.
DUCK L.
LIBARGER L.
QUIVER L.
DOGFISH L.
Quiver Beach
HAVANA
Court Wright Slough
Quiver R.



SOIL SURVEY MAP OF MASON COUNTY

terminus of the glacier would recede, and the material would be deposited somewhat irregularly over the land back of the moraines. Such a formation is known as a ground moraine. A glacier often would advance again, but not so far as before, or it would remain stationary and another moraine would be built up. These moraines, or ridges, have a steep outward slope and a very gradual inward slope.

Only one of the great glacial advances, the Illinoisan, covered the area that now constitutes Mason county. This ice sheet, no doubt, did a great deal towards leveling the surface and covering it with till. The Iowan glacier, which covered only the northern part of the state, followed the Illinoisan glacier, and while it did not reach Mason county, yet it furnished large quantities of ground-up rock material which was carried south and deposited on the flood plains of the Illinois and Mississippi rivers. From here it was carried by the wind and deposited over the upland. This material is known as loess. Mason county received its share of this deposit.

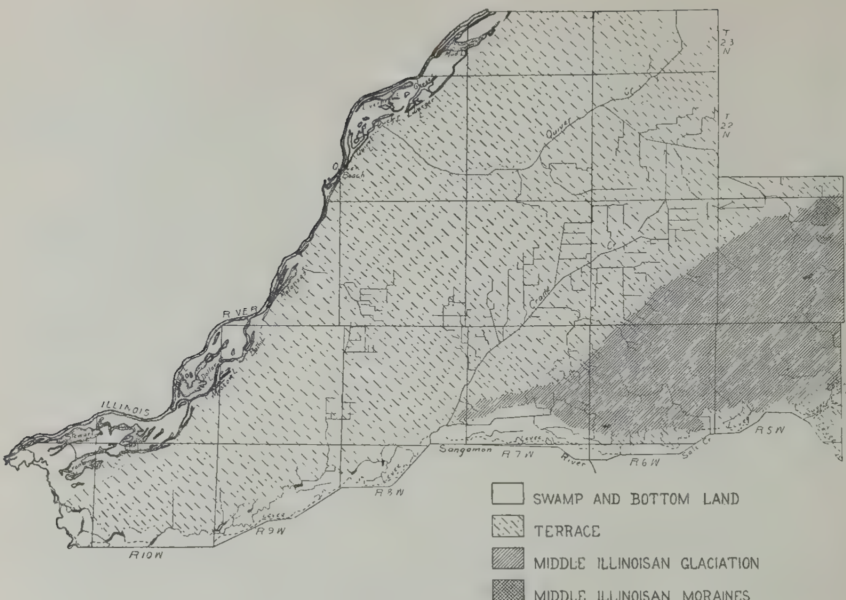
The ice of the Wisconsin glaciations, which followed the Iowan, did not reach Mason county, but the immense floods produced by the melting of these glaciers deposited large amounts of sand and gravel. The sand was later reworked by the wind, forming extensive sand dune areas. Some of it was carried to the eastward and deposited on the upland, forming a belt of upland sandy soil about four miles wide, extending in a northeast-southwest direction, with its eastern border passing thru Mason City.

PHYSIOGRAPHY AND DRAINAGE

Part of the water of Mackinaw river, and possibly of the Illinois, flowed across this county thru the Quiver creek valley, to Illinois river and thru the Crane creek valley into Sangamon river and thence into the Illinois. The lack of any distinct divide is shown by the fact that the dredge ditch of Quiver creek is continuous to Mackinaw river in Tazewell county. Dredge ditches connect the head waters of Crane and Quiver creeks.

A large part of Mason county was originally poorly drained. The central part was formerly occupied by extensive swamps and the Illinois bottom land is still swampy. These swampy conditions resulted in the formation of numerous areas of highly organic soils. A large area of peat occurs near Manito and smaller areas of peat or peaty material are found thruout the county excepting on the prairie south of San Jose. Quiver and Crane creeks are the principal natural drainage channels for the interior, while Salt creek and Sangamon river form the drainage for the south side of the county.

The western third of the county comprizes an area made up largely of sand or very sandy loam and with few exceptions the drainage of this area is good. Dredge ditches have been used to supplement the natural drainage over a considerable area in the central portion of the county. An area of about twelve sections extending north and south from Longbranch has been artificially drained. The upland part of the county comprizing that part east of Teheran is not very difficult to drain. Already over 200 miles of dredge ditches have been dug. In many cases a substratum of sand or gravel is found at a depth varying from four to ten feet, and this usually furnishes good natural drain-



MAP SHOWING THE DRAINAGE BASINS OF MASON COUNTY WITH MORAINAL, INTERMORAINAL, AND TERRACE AREAS

age. In some cases, holes are dug in the low places and filled with gravel, thus giving the water a chance to get into the coarse material beneath.

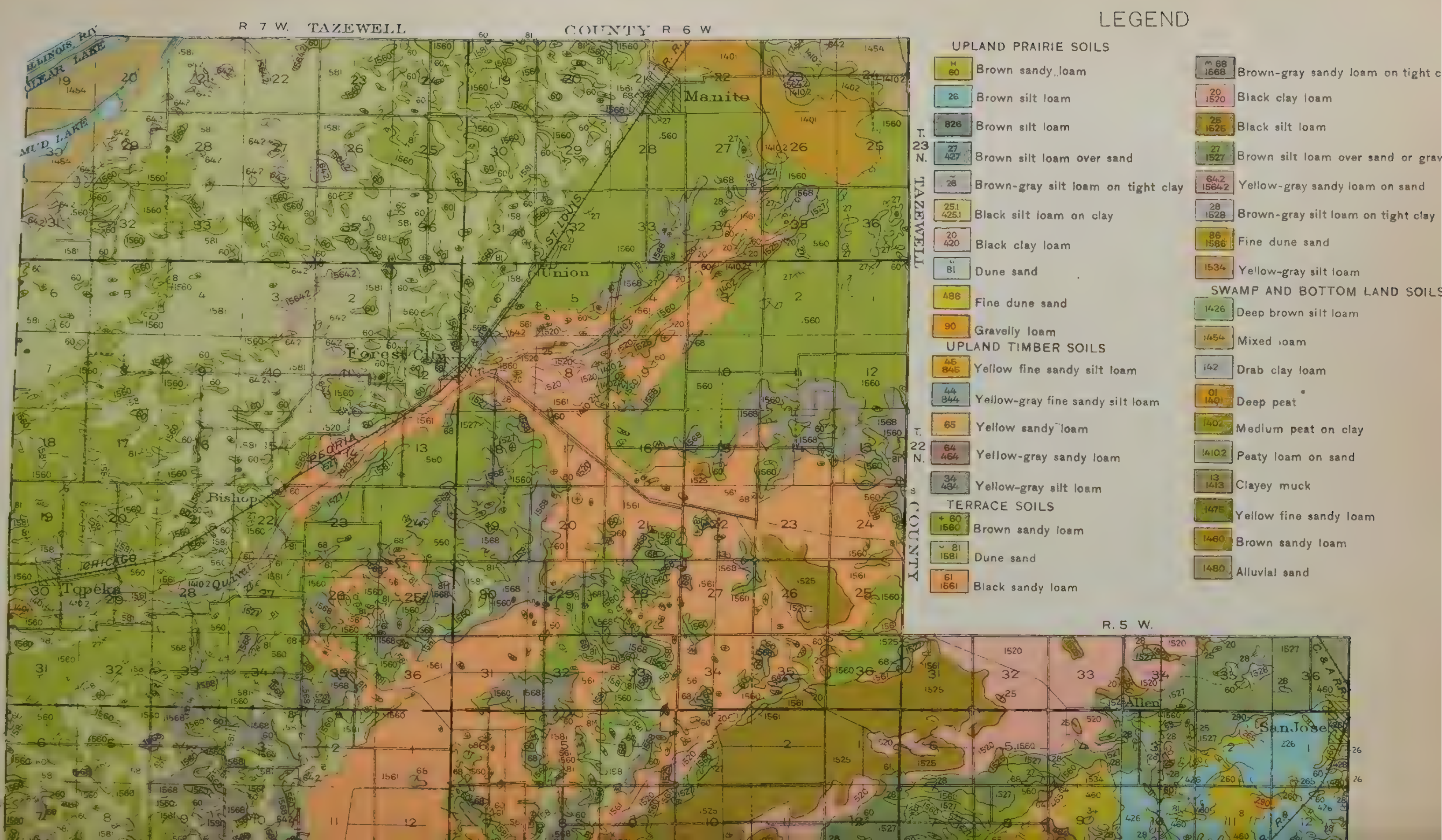
Many small ponds occur in the upland which may be drained most easily by vertical drainage. This system may be put in by boring down into sand or gravel with a post auger and putting in a 6-inch tile. The sand or gravel stratum will allow the water to escape. The drain-head should be covered so that the sediment cannot wash in. The vertical 6-inch tile is capped with a much larger tile, 12-inch, and extends up into the larger for three or four inches. The top of the larger tile should be covered with a heavy board or concrete slab and placed sufficiently deep so that when leveled it would be covered with 12 to 18 inches of soil.

The altitude of low water at Havana is 430 feet above sea level. The following are the altitudes of some of the railroad stations: Bath, 462 feet; Biggs, 501; Bishop, 490; Conover, 505; Easton, 512; Forest City, 486; Havana, 451; Kelsey, 494; Kilbourne, 495; Manito, 503; Matanzas, 465; Mason City, 581; Natrona, 576; Poplar City, 509; Quiver, 480; San Jose, 593; Saidora, 462; Teheran, 541; Topeka, 480.

SOIL TYPES

The soils of Mason county are divided into four groups, as follows:

(a) *Upland Prairie Soils,* usually rich in organic matter. These areas were originally covered with wild prairie grasses, the partially decayed roots of which have been the chief source of their organic matter. Of the prairie soils, Dune Sand contains the least organic matter.


LEGEND
UPLAND PRAIRIE SOILS
60 Brown sandy loam
26 Brown silt loam
826 Brown silt loam
27 427 Brown silt loam over sand
28 Brown-gray silt loam on tight clay
251 4251 Black silt loam on clay
20 420 Black clay loam
81 Dune sand
486 Fine dune sand
90 Gravelly loam
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45 845 Yellow fine sandy silt loam
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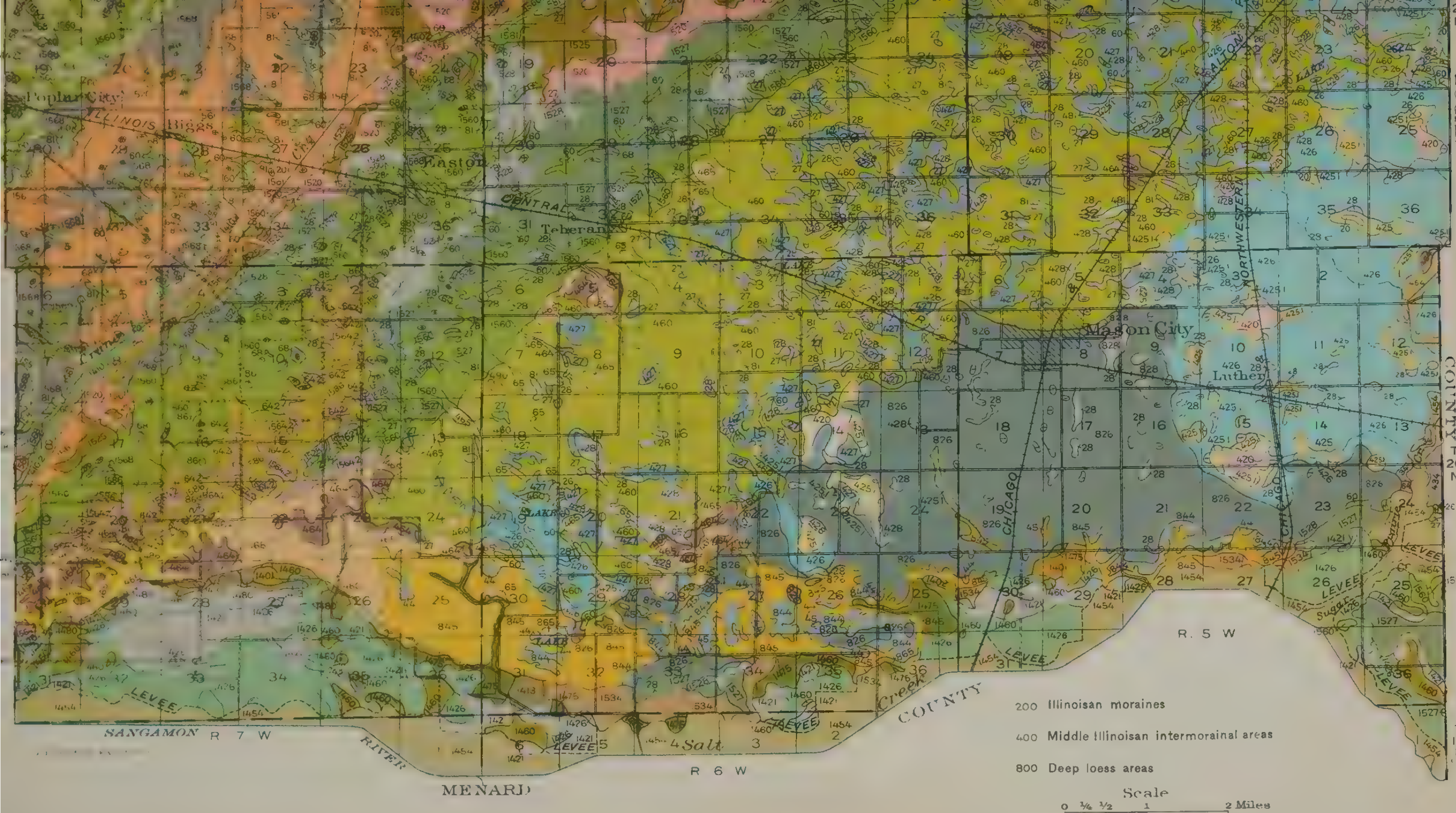
SWAMP AND BOTTOM LAND SOILS
1426 Deep brown silt loam
1454 Mixed loam
142 Drab clay loam
01 1401 Deep peat
1402 Medium peat on clay
14102 Peaty loam on sand
13 1413 Clayey muck
1475 Yellow fine sandy loam
1460 Brown sandy loam
1480 Alluvial sand
R 7 W.
TAZEWELL
COUNTY
R 6 W
R. 5 W.
T. 23 N.
T. 22 N.
ILLINOIS RIV.
CLEAR LAKE
MUD LAKE
Manito
Union
Forest City
Bishop
Topeka
Allen
San Jose
ST. LOUIS
PEORIA
CHICAGO
C. & A. R.R.



SOIL SURVEY MAP OF MASON COUNTY

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

TABLE 1.—SOIL TYPES OF MASON COUNTY

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (200, 400, 800)			
460	Brown Sandy Loam	31.01	19,846	5.60
226 426	Brown Silt Loam	18.03	11,539	3.25
826	Brown Silt Loam (loessial formation)	13.69	8,762	2.47
427	Brown Silt Loam Over Sand	8.03	5,139	1.45
428	Brown-Gray Silt Loam On Tight Clay	7.90	5,056	1.43
425.1	Black Silt Loam On Clay	2.61	1,670	.47
420	Black Clay Loam	.87	557	.16
481	Dune Sand	.66	422	.12
486	Fine Dune Sand	.63	403	.11
290 490	Gravelly Loam	.09	58	.02
		83.52	53,452	15.08
	(b) Upland Timber Soils (400, 800)			
845	Yellow Fine Sandy Silt Loam	5.46	3,495	.99
844	Yellow-Gray Fine Sandy Silt Loam	1.96	1,255	.35
465	Yellow Sandy Loam	4.55	2,912	.82
464	Yellow-Gray Sandy Loam	1.88	1,203	.34
434	Yellow-Gray Silt Loam	.19	122	.03
		14.04	8,987	2.53
	(c) Terrace Soils (1500)			
1560	Brown Sandy Loam	126.82	81,165	22.89
1581	Dune Sand	113.81	72,839	20.54
1561	Black Sandy Loam	39.13	25,043	7.06
1568	Brown-Gray Sandy Loam On Tight Clay	30.02	19,213	5.42
1520	Black Clay Loam	9.08	5,811	1.64
1525	Black Silt Loam	10.56	6,758	1.91
1527	Brown Silt Loam Over Sand or Gravel	15.76	10,087	2.84
1564.2	Yellow-Gray Sandy Loam On Sand	11.95	7,648	2.16
1528	Brown-Gray Silt Loam On Tight Clay	4.19	2,682	.76
1586	Fine Dune Sand	2.78	1,779	.50
1534	Yellow-Gray Silt Loam	1.26	806	.23
		365.36	233,831	65.95
	(d) Swamp and Bottom-Land Soils (1400)			
1426	Deep Brown Silt Loam	16.21	10,374	2.93
1454	Mixed Loam	44.24	28,314	7.98
1421	Drab Clay Loam	7.30	4,672	1.32
1401	Deep Peat	3.57	2,285	.64
1402	Medium Peat On Clay	.84	538	.15
1410.2	Peaty Loam On Sand	2.96	1,894	.53
1413	Clayey Muck	.26	166	.05
1475	Yellow Fine Sandy Loam	1.18	755	.21
1460	Brown Sandy Loam	3.48	2,227	.63
1480	Alluvial Sand	.25	160	.05
		80.29	51,385	14.49
	Water	10.78	6,899	1.95
	Total	553.99	354,554	100.00

(b) *Upland Timber Soils,* including those soils often found along stream courses over which forests grew for a long period of time. As a class, these soils contain much less organic matter than those of the prairie, because the large roots of dead trees and the surface accumulations of leaves, twigs, and fallen

trees suffered almost complete decay or were burned by forest fires. The timber soils are divided chiefly into two subgroups—the undulating and the hilly areas.

(c) *Terrace Soils,* formed by deposits from flooded streams overloaded with sediment at the time of the melting of the glaciers. Finer deposits which were later made upon the coarse, gravelly material now constitute the soil. Large quantities of sand deposited and reworked by the wind give rise to dune areas.

(d) *Swamp and Bottom-Land Soils,* which include the flood plains along streams and some poorly drained and peaty swamp areas.

Table 1 gives the area of each type of soil in Mason county and its percentage of the total area. It will be observed that 15.08 percent of the county consists of upland prairie, 2.53 percent of upland timber, 65.95 percent of terrace soils, and 14.49 percent of swamp and bottom-land soils. The accompanying map, appearing in two sections, shows the location and boundary lines of the various types.

For explanations concerning the classification of soils and the interpretation of the map and tables, the reader is referred to the first part of the Appendix to this report.

INVOICE OF THE ELEMENTS OF PLANT FOOD IN MASON COUNTY SOILS

In order to obtain a knowledge of its chemical composition, each soil type is sampled in the manner described below and subjected to chemical analysis for its important plant-food elements. For this purpose, samples are taken usually in sets of three to represent different strata in the top 40 inches of soil; namely, an upper stratum (0 to 6⅔ inches), a middle stratum (6⅔ to 20 inches), and a lower stratum (20 to 40 inches). These sampling strata correspond approximately in the common kinds of soil to 2,000,000 pounds per acre of dry soil in the upper stratum, and to two times and three times this quantity in the middle and lower strata, respectively. This, of course, is a purely arbitrary division of the soil section, very useful in arriving at a knowledge of the quantity and the distribution of the elements of plant food in the soil, but it should be borne in mind that these strata seldom coincide with the natural strata as they actually exist in the soil, and which are referred to in describing the soil types as surface, subsurface, and subsoil. By this system of sampling, we have represented separately three zones for plant feeding. The upper, or surface layer includes at least as much soil as is ordinarily turned with the plow, and this is the part with which the farm manure, limestone, phosphate, or other fertilizing material is incorporated.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed. It should be understood, however, that the rate of liberation from their insoluble forms, a matter of equal importance, is governed by many factors.

For convenience in making application of the chemical analyses the results as presented here have been translated from the percentage basis and are given in the accompanying tables in terms of pounds per acre. In this, the assumption

is made that for ordinary types a stratum of dry soil of the area of an acre and 6⅔ inches thick weighs 2,000,000 pounds, exceptions being made of certain soils very high in organic matter, such as the peats and the mucks. It is understood, of course, that this value is only an approximation but it is believed that, with this understanding, it will suffice for the purposes intended. It is a simple matter to convert these figures back to the percentage basis in case one desires to consider the information in that form.

THE UPPER SAMPLING STRATUM

In Table 2 are reported the amount of organic carbon (which serves as a measure of the total organic matter), and the total quantities of nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium in 2 million pounds of the surface soil (the plowed soil of an acre about 6⅔ inches deep) of each type in Mason county.

Because of the extreme variations frequently found within a given soil type with respect to the presence of limestone and acidity in the different strata, no attempt is made to include in the tabulated results figures purporting to represent their averages in the respective types. In examining each soil type in the field, however, numberous qualitative tests are made which furnish general information regarding the soil reaction, and in the discussions of the individual soil types which follow, recommendations based upon these tests are given concerning the lime requirement of the respective types. Such recommendations cannot be made specific in all cases because local variations exist, and because the lime-requirement may change from time to time, especially under cropping and treatment. Therefore, it is usually desirable to determine the lime-requirement for a given field and in this connection the reader is referred to the section in the Appendix dealing with the application of limestone (page 39).

In connection with Table 2, it is of interest to note the variation among the different soil types with respect to their content of the various plant-food elements. It will be seen from the analyses that variations in the organic-carbon content of the different soils are accompanied by similar variations in the nitrogen content. (The organic-carbon content is usually from 10 to 14 times that of total nitrogen.) This close relationship is explained by the well established facts that all soil organic matter contains nitrogen and that most of the soil nitrogen (usually 99 percent or more) is present in a state of organic combination. Such a consistent relationship, which is also maintained in the middle and lower sampling strata, is not to be observed between any of the other elements. A less marked, tho positive correlation, exists with respect to sulfur and organic matter. The organic matter with its nitrogen exhibits extreme variations in amount in the different soils of the county because of the presence both of peaty soils, which are composed mainly of organic matter, and of sands, which are characteristically deficient in it. The smallest amounts of organic carbon and nitrogen are found in Dune Sand and Alluvial Sand. The Alluvial Sand (to a depth of 6⅔ inches) contains 3,380 pounds of organic carbon per acre and 260 pounds of nitrogen. The largest amounts of both organic carbon and nitrogen are found in Deep Peat, which contains 440,880 pounds of organic carbon and 35,100 pounds of total nitrogen in one million pounds of the upper stratum (0 to 6⅔

inches). The carbon thus amounts to 44 percent of the soil and since organic matter is about half carbon, this soil consists of approximately 88 percent of organic matter. On the basis of the 6⅔-inch stratum, Deep Peat contains about 130 times as much organic matter and nitrogen as Alluvial Sand.

The large proportion of sandy soils in Mason county, 67.79 percent of the entire area, makes a consideration of these soil types of particular importance. The average organic-carbon content of these soils, including sixteen soil types, is 19,920 pounds per acre in the upper 6⅔ inches while the nitrogen content averages 1,610 pounds. These amounts are very low, being only about two-fifths as much as the quantities of these two elements present in the fifteen silt loam and clay loam types, which amount to 50,240 pounds of carbon and 4,350 pounds of nitrogen per acre. The loose, open character of sandy soils, which permits the ready access of air, encourages the rapid decomposition of organic materials thus making the maintenance of organic matter and nitrogen on such soils a particularly difficult problem. These considerations serve to emphasize the necessity of giving particular attention to the return of organic materials to soils of this group in planning crop rotations. The only sandy soil type in the county which is naturally well supplied with organic matter and nitrogen is the Black Sandy Loam.

It may be noted that the timber soils, as a rule, are light in color (yellow or yellowish gray) and are also rather poorly supplied with organic matter and nitrogen; while the prairie soils, which are generally brown or black in color, contain much larger quantities of these two materials.

With the exception of the nitrogen, sulphur, and organic-matter correlations previously mentioned, the elements vary independently and within a fairly wide range as a rule. Thus the phosphorus content varies from 440 pounds per acre in Dune Sand, Terrace, and in Yellow Sandy Loam, to 3,420 pounds in Clayey Muck, Bottom. Magnesium ranges from 2,340 pounds in Dune Sand, Upland, to a maximum of 31,860 pounds in Black Silt Loam, while total calcium ranges from 3,920 pounds in Dune Sand to 163,860 in Clayey Muck. The extremely large amounts of calcium are accounted for by the presence in the soil of calcium carbonate (limestone). The potassium content of all the soils is fairly constant between 25,000 and 35,000 pounds per acre, with the exception of the soils containing very large amounts of organic matter, particularly the peaty soils. The peaty soils, containing as low as 2,930 pounds of potassium per acre, are so markedly deficient in this element as to make potassium fertilization very frequently a necessity for successful crop production.

THE MIDDLE AND LOWER SAMPLING STRATA

In Tables 3 and 4 are recorded the amounts of the plant-food elements in the middle and lower sampling strata. In comparing these strata with the upper one, it will be noted that in the majority of soil types the proportion of organic matter and nitrogen diminish rather rapidly with increasing depth. On the other hand, the middle and lower strata contain as a rule practically as large a percentage of the mineral elements as the upper stratum. In thus making comparisons, on the basis of percentage, the data as given for the middle and lower

TABLE 2.—PLANT-FOOD ELEMENTS IN THE SOILS OF MASON COUNTY, ILLINOIS
UPPER SAMPLING STRATUM: ABOUT 0 TO 6⅔ INCHES
AVERAGE POUNDS PER ACRE IN 2 MILLION POUNDS OF SOIL

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (200, 400, 800)							
460	Brown Sandy Loam	22 850	1 860	740	310	31 010	5 150	6 910
426	Brown Silt Loam	49 180	4 020	1 100	580	36 300	7 540	8 160
826	Brown Silt Loam (Loessial)	42 740	3 680	1 060	680	37 080	8 480	9 020
427	Brown Silt Loam Over Sand	37 420	3 320	1 020	640	34 020	5 060	6 160
428	Brown-Gray Silt Loam On Tight Clay	57 680	7 000	1 500	920	36 720	5 720	7 560
425.1	Black Silt Loam On Clay	68 360	5 420	1 440	620	38 160	10 460	15 000
420	Black Clay Loam	81 600	6 040	1 680	1 140	34 900	12 260	21 220
481	Dune Sand	9 780	600	520	260	25 760	2 340	3 920
486	Fine Dune Sand	6 200	340	540	220	26 880	3 160	7 160
290	Gravelly Loam	14 980	1 200	700	400	22 040	5 100	5 400
	Upland Timber Soils (400, 800)							
845	Yellow Fine Sandy Silt Loam	27 780	2 380	680	340	34 860	5 140	8 640
844	Yellow-Gray Fine Sandy Silt Loam	24 420	2 180	780	420	35 600	6 640	8 020
465	Yellow Sandy Loam	10 540	920	440	220	30 520	4 580	8 260
464	Yellow-Gray Sandy Loam	15 020	1 080	480	220	33 460	4 020	8 200
434	Yellow-Gray Silt Loam	28 400	2 920	900	420	38 740	6 160	8 300
	Terrace Soils (1500)							
1560	Brown Sandy Loam	21 280	1 700	810	370	27 090	4 410	5 480
1581	Dune Sand	9 040	590	440	170	19 430	3 140	5 450
1561	Black Sandy Loam	50 560	4 160	1 440	720	21 220	8 040	13 940
1561	Black Sandy Loam (Alkali)	71 720	6 480	1 460	1 060	20 840	11 460	105 200
1568	Brown-Gray Sandy Loam On Tight Clay	22 370	1 930	650	360	31 210	3 460	6 110
1520	Black Clay Loam	113 080	8 760	1 720	1 780	25 720	14 720	26 920
1525	Black Silt Loam	55 280	5 180	1 660	820	33 060	31 860	51 580
1527	Brown Silt Loam Over Sand or Gravel	49 400	3 940	1 260	660	38 000	7 480	10 520
1564.2	Yellow-Gray Sandy Loam On Sand	11 260	900	540	200	28 320	3 160	4 960
1528	Brown-Gray Silt Loam On Tight Clay	32 940	2 760	840	500	34 180	5 760	9 080
1586	Fine Dune Sand	11 080	820	480	240	23 300	3 220	6 480
1534	Yellow-Gray Silt Loam	26 400	2 480	900	420	38 920	6 220	7 660
	Swamp and Bottom-Land Soils (1400)							
1426	Deep Brown Silt Loam	44 240	4 360	1 960	700	38 240	13 760	15 200
1454	Mixed Loam[1]	....	....	....	....	....	....	....
1421	Drab Clay Loam	51 900	4 240	1 760	880	39 740	15 760	15 300
1401	Deep Peat[2]	440 880	35 100	1 820	5 250	2 930	4 060	34 440
1402	Medium Peat On Clay[2]	370 960	30 150	1 830	4 280	5 040	3 380	27 880
1410.2	Peaty Loam On Sand[3]	144 600	10 180	2 470	1 490	14 890	4 900	19 130
1413	Clayey Muck[3]	201 800	18 530	3 420	2 880	12 770	8 640	163 860
1475	Yellow Fine Sandy Loam	14 780	1 500	1 120	300	36 820	19 280	30 200
1460	Brown Sandy Loam	38 040	3 360	1 360	700	32 300	10 840	13 360
1480	Alluvial Sand	3 380	260	640	140	25 420	12 080	24 180

LIMESTONE and SOIL ACIDITY.—In connection with these tabulated data, it should be explained that the figures for limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in the form of numerical averages reliable information concerning the limestone requirement for a given soil type. A general statement, however, will be found concerning the lime requirement of the respective soil types in connection with the discussions which follow.

[1] On account of the heterogeneous character of the Mixed Loam, chemical analyses are not included for this type.

[2] Amounts reported are for 1 million pounds of Deep Peat and Medium Peat on Clay.

[3] Amounts reported are for 1½ million pounds of Peaty Loam On Sand and Clayey Muck.

TABLE 3.—PLANT-FOOD ELEMENTS IN THE SOILS OF MASON COUNTY, ILLINOIS
MIDDLE SAMPLING STRATUM: ABOUT 6⅔ TO 20 INCHES
AVERAGE POUNDS PER ACRE IN 4 MILLION POUNDS OF SOIL

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (200, 400, 800)							
460	Brown Sandy Loam	43 100	3 840	1 580	860	63 220	11 820	14 280
426	Brown Silt Loam	75 200	6 880	2 120	1 120	75 280	18 120	17 840
826	Brown Silt Loam (Loessial)	68 040	6 320	2 080	1 160	76 960	19 880	18 160
427	Brown Silt Loam Over Sand	66 480	5 960	1 800	1 200	68 560	15 440	11 760
428	Brown-Gray Silt Loam On Tight Clay	32 720	3 600	1 880	560	79 640	10 440	14 880
425.1	Black Silt Loam On Clay	96 880	7 840	2 320	880	77 880	22 200	31 200
420	Black Clay Loam	95 400	6 960	2 520	1 760	68 920	28 840	43 040
481	Dune Sand	14 800	720	1 040	480	50 000	4 120	8 320
486	Fine Dune Sand	9 320	480	960	440	54 520	7 000	10 400
290	Gravelly Loam	22 760	1 920	1 200	920	43 720	10 280	9 360
	Upland Timber Soils (400, 800)							
845	Yellow Fine Sandy Silt Loam	17 120	2 000	1 400	360	73 080	16 880	15 080
844	Yellow-Gray Fine Sandy Silt Loam	22 040	2 600	1 560	600	71 960	23 200	13 240
465	Yellow Sandy Loam	11 880	1 160	880	440	63 040	10 080	14 840
464	Yellow-Gray Sandy Loam	13 160	1 360	920	440	68 040	9 200	15 920
434	Yellow-Gray Silt Loam	21 600	2 440	2 080	440	80 160	21 920	14 760
	Terrace Soils (1500)							
1560	Brown Sandy Loam	42 250	3 530	1 690	830	55 240	9 780	11 310
1581	Dune Sand	9 040	680	820	230	39 050	6 280	10 570
1561	Black Sandy Loam	58 800	4 520	2 280	1 200	41 920	15 880	23 640
1561	Black Sandy Loam (Alkali)	88 200	8 360	2 360	1 240	43 080	21 600	183 400
1568	Brown-Gray Sandy Loam On Tight Clay	24 160	2 420	880	520	65 940	10 580	12 160
1520	Black Clay Loam	95 200	6 760	2 560	1 880	52 760	35 000	48 160
1525	Black Silt Loam	62 440	6 400	2 800	960	67 360	61 960	100 040
1527	Brown Silt Loam Over Sand or Gravel	71 120	6 280	2 120	1 040	79 200	18 640	17 160
1564.2	Yellow-Gray Sandy Loam On Sand	10 760	1 000	840	200	56 200	5 720	11 200
1528	Brown-Gray Silt Loam On Tight Clay	38 720	3 760	1 200	640	71 720	15 840	18 840
1586	Fine Dune Sand	11 320	840	760	240	49 120	6 240	11 760
1534	Yellow-Gray Silt Loam	21 320	2 520	1 560	440	82 680	19 680	13 400
	Swamp and Bottom-Land Soils (1400)							
1426	Deep Brown Silt Loam	83 280	7 280	3 040	1 560	71 760	27 160	29 080
1454	Mixed Loam[1]	......	......	......	......	......	......	......
1421	Drab Clay Loam	66 240	6 200	2 280	1 560	76 080	30 200	28 480
1401	Deep Peat[2]	854 620	65 780	2 170	11 000	5 510	9 610	68 220
1402	Medium Peat On Clay[2]	486 440	32 640	1 860	5 960	21 720	9 620	38 280
1410.2	Peaty Loam On Sand[3]	143 470	8 280	2 000	1 400	38 460	10 460	26 160
1413	Clayey Muck[3]	391 650	28 860	5 400	4 290	34 710	15 960	143 490
1475	Yellow Fine Sandy Loam	39 160	3 800	2 160	560	74 720	29 200	47 280
1460	Brown Sandy Loam	44 680	4 160	1 840	960	60 040	18 400	23 360
1480	Alluvial Sand	4 640	360	960	240	51 440	25 440	52 280

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1] On account of the heterogeneous character of Mixed Loam, chemical analyses are not included for this type.
[2] Amounts reported are for 2 million pounds of Deep Peat and Medium Peat On Clay.
[3] Amounts reported are for 3 million pounds of Peaty Loam On Sand and Clayey Muck.

sampling strata should be divided by two and three respectively.

It is frequently of interest to know the total supply of a plant-food element accessible to the growing crops. While it is impossible to obtain this information

TABLE 4.—PLANT-FOOD ELEMENTS IN THE SOILS OF MASON COUNTY, ILLINOIS
LOWER SAMPLING STRATUM: ABOUT 20 TO 40 INCHES
AVERAGE POUNDS PER ACRE IN 6 MILLION POUNDS OF SOIL

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (200, 400, 800)							
460	Brown Sandy Loam......	34 350	3 330	1 950	900	94 140	20 190	20 490
426	Brown Silt Loam.........	68 580	6 300	2 400	1 020	118 560	33 180	24 600
826	Brown Silt Loam (Loessial)	66 000	6 060	2 940	1 440	117 240	37 680	28 020
427	Brown Silt Loam Over Sand	47 820	4 200	2 280	1 320	105 480	26 640	14 940
428	Brown-Gray Silt Loam On Tight Clay............	19 320	2 400	3 120	780	120 720	25 860	30 540
425.1	Black Silt Loam On Clay..	58 560	4 680	2 880	540	115 140	46 560	49 320
420	Black Clay Loam.........	107 940	3 660	2 940	2 160	84 360	115 140	451 080
481	Dune Sand..............	9 360	780	1 560	600	77 460	8 220	16 560
486	Fine Dune Sand..........	10 200	900	1 980	600	90 780	19 320	21 180
290	Gravelly Loam...........	19 800	1 400	1 620	960	62 940	14 340	13 380
	Upland Timber Soils (400, 800)							
845	Yellow Fine Sandy Silt Loam	24 720	2 760	2 880	900	105 000	38 400	24 120
844	Yellow-Gray Fine Sandy Silt Loam................	22 140	2 880	2 400	1 020	107 940	40 860	21 600
465	Yellow Sandy Loam......	14 940	1 980	1 740	660	98 160	22 320	22 440
464	Yellow-Gray Sandy Loam..	19 140	2 400	2 220	900	105 960	34 440	22 140
434	Yellow-Gray Silt Loam....	17 820	2 520	3 660	480	119 580	45 300	22 920
	Terrace Soils (1500)							
1560	Brown Sandy Loam......	38 160	3 350	2 150	1 250	80 540	16 730	15 290
1581	Dune Sand..............	11 160	900	1 170	450	58 800	9 500	16 050
1561	Black Sandy Loam.......	52 800	3 660	4 020	600	66 420	26 400	47 000
1561	Black Sandy Loam (Alkali)	52 620	4 500	3 360	1 020	76 920	31 020	76 320
1568	Brown-Gray Sandy Loam On Tight Clay.........	23 370	2 460	1 890	810	96 330	24 180	21 360
1520	Black Clay Loam.........	70 020	4 500	3 900	1 980	87 840	91 980	340 380
1525	Black Silt Loam..........	43 500	4 080	3 240	1 320	103 560	96 840	149 220
1527	Brown Silt Loam Over Sand or Gravel.............	65 220	5 460	2 700	1 200	113 400	40 200	24 960
1564.2	Yellow-Gray Sandy Loam On Sand...............	12 180	1 320	1 800	240	84 180	12 360	15 540
1528	Brown-Gray Silt Loam On Tight Clay............	34 020	3 300	2 340	900	102 360	45 420	35 880
1586	Fine Dune Sand..........	11 520	960	1 260	420	73 140	10 620	18 060
1534	Yellow-Gray Silt Loam....	25 440	3 360	3 120	600	119 520	44 160	21 420
	Swamp and Bottom-Land Soils (1400)							
1426	Deep Brown Silt Loam....	75 720	6 300	3 180	1 260	105 000	34 440	39 480
1454	Mixed Loam[1]............	....	....	....	....	....	....	....
1421	Drab Clay Loam.........	56 760	5 100	2 280	1 680	111 840	45 420	38 100
1401	Deep Peat[2]..............	1 293 030	93 210	2 910	14 360	10 250	14 360	99 560
1402	Medium Peat On Clay[3] ...	238 640	17 460	2 210	14 040	97 380	35 780	46 670
1410.2	Peaty Loam On Sand.....	46 140	1 980	1 650	6 870	86 760	32 130	56 040
1413	Clayey Muck[3]...........	140 220	8 550	1 940	2 430	74 880	22 500	49 450
1475	Yellow Fine Sandy Loam..	84 360	7 260	3 720	960	109 620	30 360	50 520
1460	Brown Sandy Loam......	31 620	3 000	2 040	1 020	88 800	26 820	32 280
1480	Alluvial Sand...........	14 100	1 140	1 560	300	86 640	40 140	81 480

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1] On account of the heterogeneous character of Mixed Loam, chemical analyses are not included for this type.
[2] Amounts reported are for 3 million pounds of Deep Peat.
[3] Amounts reported are for 4½ million pounds of Medium Peat On Clay and Clayey Muck.

exactly, especially for the deeper-rooted crops, it seems probable that most of the feeding range of the roots of the majority of our common field crops is included in the upper 40 inches of soil. By adding together for a given soil type,

the corresponding figures in Tables 2, 3, and 4, the total amounts of the respective plant-food elements to a depth of 40 inches may be ascertained.

A wide range of variation with respect to composition is found to occur in the sub-layers as well as in the top layer of the various soil types. The tables reveal further that there is not only this wide diversity among the different soils with respect to a given plant-food element, but that there is also a great variation with respect to the relative abundance of the various elements within a given soil type, as measured by crop requirements. For example, in the most extensive soil type in the county, Brown Sandy Loam, Terrace, we find that the total quantity of nitrogen in an acre to a depth of 40 inches amounts to 8,580 pounds. This is about the amount of nitrogen contained in 8,580 bushels of corn. The amount of phosphorus, 4,650 pounds, contained in the same soil is equivalent to that contained in 27,300 bushels of corn, while in the same quantity of this soil, there is present 162,870 pounds of potassium, the equivalent of that contained in 860,000 bushels of corn. In marked contrast to this soil is the Deep Peat, which contains in the 40-inch stratum approximately 194,000 pounds per acre of nitrogen, an amount equal to that in 194,000 bushels of corn. The phosphorus content is 6,900 pounds, or the equivalent of 40,600 bushels of corn, while the total amount of potassium is only 18,690 pounds, equivalent to 98,000 bushels of corn.

These statements are not intended to imply that it is possible to predict how long it might be before a certain soil would become exhausted under a given system of cropping. Neither do the figures necessarily indicate the immediate procedure to be followed in the improvement of a soil, for other factors enter into consideration, aside from the mere amount of plant-food elements present in the soil. Much depends upon the nature of the crops to be grown as to their utilization of plant-food materials, and much depends upon the condition of the plant-food substances themselves as to their availability. Finally in planning the detailed procedure for the improvement of a soil, there enter for consideration all the economic factors involved in any fertilizer treatment. Such figures do, however, furnish an inventory of the total stocks of the plant-food elements that can possibly be drawn upon, and in this way these chemical data contribute fundamental information for the intelligent planning, in a broad way, of systems of soil management for conserving and improving the fertility of the land.

DESCRIPTION OF INDIVIDUAL SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of Mason county occupy 83.52 square miles, or 15.08 percent of the area of the county. They occur in the eastern part of the county east of the line running northeast and southwest thru Teheran.

The dark color of prairie soils is due to the accumulation of organic matter, which is derived very largely from the fibrous roots of prairie grasses. The network of grass roots was protected from rapid and complete decay owing to the rather effective exclusion of oxygen by the covering of fine, moist soil, and by the mat of vegetative material formed by old grass stems and leaves. On the native prairies the stems and leaves of the grasses were, in part, burned by

prairie fires or were lost in part thru decay, so that they actually added little organic matter to the soil; however, the protection afforded by this mat of constantly renewed decaying material was of importance in retarding the decay of the roots. From a sample of virgin bluestem sod, one of the most common prairie grasses, it has been determined that an acre of this soil to a depth of 7 inches may contain as high as 13½ tons of roots.

Brown Sandy Loam (460)

Brown Sandy Loam is the most extensive of the upland types in Mason county and occurs principally in a belt about five miles wide bordering the edge of the terrace which runs thru Teheran. Its presence in this border belt is due largely, if not entirely, to the movement of sand by the wind from the terrace on to the upland. It is possible that during periods of high water some of the sand in the low places may have been deposited as alluvial sand. Brown Sandy Loam, Upland, covers an area of 31.01 square miles, or 5.60 percent of the area of the county. Topographically, practically all of the area varies from undulating to rolling, and in some places erosion is doing considerable damage. Even tho the type is rather porous, the rolling character of the land gives the surplus water or run-off a chance to do a great deal of damage by erosion. The tendency to erode in spite of the porosity of the soil is due to its incoherent nature.

The surface soil, which is about 8 inches deep, is a brown to grayish brown sandy loam. Areas of Dune Sand which are too small to be shown on the map frequently occur. Brown Sandy Loam as it occurs in this county is very low in organic matter for a prairie type. The subsurface is from 5 to 10 inches in thickness. It varies in color from brownish yellow to yellow, and in physical composition from a loam to a sand, altho a sandy loam subsurface is most frequently found. The subsoil, which is found at a depth of 13 to 18 inches, is yellow in color and varies from sandy silt to almost pure sand. It is only slightly compact and shows very good aeration.

Management.—The organic-matter and nitrogen contents of this type are comparatively low, and in its management the maintenance and increase of these constituents are most important. This type shows considerable variation in lime requirement, but as a rule about 2 tons of limestone per acre are needed for the growth of clovers, which are necessary for maintaining the nitrogen. Red, mammoth, or sweet clover are the best kinds to grow. Cowpeas may be grown on the extreme sandy phases to good advantage. The phosphorus content of this type is not high; however the permeability of soil of this kind permits deep rooting and thus increases the feeding range of the roots to such an extent that in reality large quantities of phosphorus are within the feeding zone.

One of the greatest difficulties in the management of this type is the prevention of gullying. The subsoil is rather incoherent, and where a waterfall gully starts, the undermining action of the falling water goes on very rapidly, thus forming a gully which is very difficult to stop. Probably one of the best means for preventing further damage when a gully is once started is by means of straw dams held in place by woven or barb wire fences crosswise of the gully. It may be necessary in some cases to use a double fence, placing the lines about three feet apart. The space between the fences is filled with straw, making an effective

FIG. 1.—DAMS OF STRAW HELD BY WOVEN WIRE FENCING

dam. Concrete dams may be used but they are very expensive, and are no more effective than the straw dam. It is very necessary in the construction of either straw or concrete dams to guard against the water cutting around the ends of the dam. The cheapness of straw dams permits the use of large numbers, and if necessary, they can be placed every few rods to prevent washing and also to encourage the filling of the gully. Earth dams may be used to good advantage. An opening should be made into a tile above the dam so the water will not run

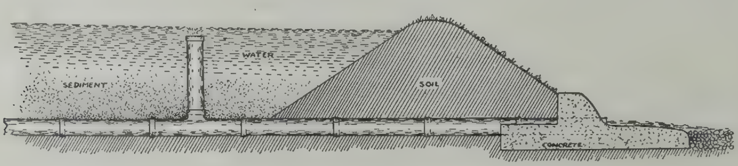


FIG. 2.—DAM OF EARTH

over it and wash it out. The diagram shows the construction of the dam and the location of the tile. Great care should be exercised in plowing up draws. It would be much better to sod them down permanently. This is practiced in some localities with excellent success.

Brown Silt Loam (426)

The upland Brown Silt Loam occurs principally in the two eastern townships, and covers an area of 18.03 square miles, or 3.25 percent of the area of the county. This type occupies slightly undulating to rolling areas of the prairie land. Most of it is well surface-drained, but some areas require artificial drainage.

The surface soil, which is about 9 inches deep, is predominantly a brown silt loam containing more than the usual amount of sand. It varies, however, from black as it grades into Black Clay Loam or Black Silt Loam, to light brown as it grades into Brown Sandy Loam. The subsurface extends to a depth of 18 to 22 inches and varies from brownish yellow to yellow silt loam. The subsoil,

FIG. 3.—A SODDED DRAW AFTER PLOWING THE FIELD

beginning at a depth of 18 to 22 inches, is a fairly compact yellow silt loam or clayey silt loam with enough fine sand to prevent the development of high plasticity.

Management.—This type is readily pervious to air and water, and under-drainage is a comparatively easy matter where a good outlet can be obtained. The type shows a slight to medium acidity, the degree of acidity being about the same as in Brown Sandy Loam (460). Applications of limestone of about 2 tons per acre are necessary before best results can be secured with the clovers, altho alsike clover does well and red clover fairly well without lime on

FIG. 4.—FIELD SHOWN IN FIGURE 3 AFTER PREPARING FOR PLANTING

much of the area. The same precautions are necessary in regard to the turning under of legumes and crop residues as for Brown Sandy Loam. The phosphorus content of this type is fairly high. The results from experiment fields located on similar soil seem to indicate that it is questionable whether rock phosphate when used at the rate of one ton per acre every four years in connection with limestone and manure or crop residues will increase yields sufficiently to pay for its cost. No information is available as to whether lighter applications of this material would prove profitable or not. Results from the Bloomington experiment field which is located on similar soil show a good profit from the use of steamed bone meal at the rate of 200 pounds per acre every year. Sufficient data are not available regarding acid phosphate to justify making any recommendation either for or against its use on this type of soil. If either steamed bone meal or acid phosphate is used, it should be applied broadcast after plowing for wheat, and thoroly worked in during the preparation of the seed bed, or else drilled in at the time of, or just before, drilling the wheat.

Suggestions for practical systems of cropping will be found in the discussion of crop rotations in the Appendix, on page 46. For the results of field experiments on this type of soil, see page 51 of the Supplement.

Brown Silt Loam (826) (Deep Loess Area)

Brown Silt Loam of the deep loess area occurs in the southeastern part of the county where deep wind deposits have been formed by fine material carried from the bottom land along Salt creek and the Sangamon river. The topography of this type is rolling and somewhat similar to that of dune formation. The type covers an area of 13.69 square miles, or 2.47 percent of the area of the county.

The surface soil, which is about 8 inches deep, is a brown silt loam containing nearly enough fine sand to be classed as a fine sandy loam. The subsurface extends to a depth of about 20 inches and is a yellowish brown fine sandy silt loam. The subsoil is a yellow silty clay loam and is compact, tho not impervious. This compact condition is less pronounced as the northern boundary of the type is approached.

Management.—This type requires the same management as Brown Silt Loam (426). It is, however, better drained naturally because of rolling topography, altho in the flatter portion of the area in the vicinity of Mason City underdrainage is necessary and, as a general rule, it is probably more in need of limestone than is Brown Silt Loam (426).

Brown Silt Loam Over Sand (427)

Brown Silt Loam Over Sand occurs principally in the area of Brown Sandy Loam. The sand is found at various depths from 3 to 6 feet. The type generally occupies the lower and flatter areas, but there are exceptions to this rule. The total area of the type is 8.03 square miles, or 1.45 percent of the area of the county. The topography is flat to slightly rolling, being distinctly dune-like in some places.

The surface soil, which is about 8 inches in depth, is a brown silt loam containing a fairly good supply of organic matter in the lower and flatter areas,

while in the higher more rolling areas the organic-matter content is relatively low, as indicated by the light brown color. The sand content of the surface soil of the type varies considerably and is, in general, higher than that usually found in silt loams. Numerous low mounds occur thruout the area of this type which were undoubtedly formed as dunes. These mounds are sandy loam rather than silt loam, but they are not large enough to be shown as separate types on the map. The subsurface is a light brown to yellowish brown silt loam 6 to 18 inches in thickness, varying in texture in the same way as the surface soil. The subsoil is a yellow silty material containing a considerable amount of fine sand.

Management.—All strata are pervious to water, and drainage is comparatively easy. Very little artificial drainage is necessary because of the sand subsoil. The same treatment should be applied to this type as to the Brown Silt Loam (426).

Brown-Gray Silt Loam On Tight Clay (428)

Brown-Gray Silt Loam On Tight Clay is very irregularly distributed over the upland. It is frequently found in the low undrained areas in the Brown Sandy Loam. Small ponds sometimes occur in these areas. The type covers an area of 7.90 square miles, or 1.43 percent of the area of the county.

The surface soil, which is 7 to 10 inches in depth, is usually a grayish brown silt loam containing more sand than is ordinarily found in a silt loam. The subsurface, which is 6 to 10 inches in thickness, is a gray or almost white silty or fine sandy material. This passes very abruptly into a mottled yellow or mottled drab clay, which is very plastic and impervious. This impervious stratum is usually about 12 inches thick and rests on a very friable, mottled yellow silty or fine sandy material.

Management.—This soil is acid, and about 3 to 4 tons of limestone should be applied as an initial application with subsequent applications of about 2 tons per acre when needed, as indicated by clover growth. This type is well supplied with all the elements of plant food. Much of the organic matter which is present in larger amounts than is usual for this type has reached the resistant stage in its decay. It is necessary, for this reason, to make systematic additions of fresh organic matter if the soil is to respond as it should to good tillage methods. The greatest natural difficulty encountered in the economical and efficient management of this type is poor drainage. The presence of the tight clay subsoil makes tiling expensive because the strings must be placed closer together than in more open subsoils and there is always the uncertainty as to whether the tile will draw with sufficient rapidity to be effective. Surface drainage, tho not entirely satisfactory, has to be depended on to a large extent for this type of soil.

Black Silt Loam On Clay (425.1)

Black Silt Loam On Clay occurs in the upland, associated with Brown Silt Loam, and usually occupies depressions, probably where Black Clay Loam has been buried by silty material washed in from the upland. It covers an area of 2.61 square miles, or .47 percent of the area of the county.

The surface soil, which is 8 to 12 inches in depth, is a black clayey silt loam, varying to a black silt or black sandy silt loam. It is well supplied with organic

matter. The subsurface consists of a stratum about 12 inches in thickness and varies from a black clayey silt loam to a black clay, usually becoming drabbish in color with increasing depth. The subsoil consists of a mottled yellowish drab or olive colored clay, varying to a yellow clay in local patches.

Management.—This type is becoming slightly acid in the surface in some areas. Carbonate, however, is usually found at a depth of 30 to 40 inches. It is well supplied with phosphorus and all of the other elements of plant food. The most important considerations in the management of this type are to provide good underdrainage and to maintain the organic-matter and nitrogen contents. Limestone is now needed on some of the areas, and as time goes on, areas not now needing this material will become acid.

Black Clay Loam (420)

Black Clay Loam, from the standpoint of area, is an unimportant type in Mason county. The total area covered by this type is only .87 square mile, or .16 percent of the area of the county. It occupies low areas in the upland.

The surface soil, which is about 9 inches in depth, is a black, granular, plastic clay loam. It is well supplied with organic matter. The subsurface is about 10 inches in thickness and varies from a black clay loam to a yellowish drab or olive color. The subsoil is a mottled drab or yellowish drab clay.

Management.—Under-drainage is the first requirement of this type, and this, together with good cultivation and the growing of legume crops and turning under of residues to maintain good tilth, are all the considerations necessary in its management. All strata contain more or less limestone.

Dune Sand (481)

The upland Dune Sand occurs principally within a distance of five miles from the edge of the terrace. It is present on the upland largely thru the action of wind which carried sand from the terrace. The dunes are very irregular in their distribution and shape. This type covers an area of .66 square mile, or .12 percent of the area of the county.

The surface consists of a light brownish yellow, incoherent sand, which is very low in organic matter. There is no distinct subsurface and subsoil development. There is no change with depth excepting that the color is yellow below about 7 inches.

Management.—(See also Management of Dune Sand, Terrace, page 22). The acidity of this type varies from slight to strong. No carbonates are present to a depth of 40 inches, tho the degree of acidity frequently decreases with depth. Two tons of limestone per acre is sufficient for the growth of sweet clover excepting on the most acid areas where 3 or even 4 tons may be required. This type, after treatment with limestone, will grow good sweet clover. Following sweet clover, bluegrass will do fairly well. The type is very low in nitrogen. It is also low in phosphorus and sulfur, and probably in available potassium. Limestone on the Oquawka field, which is located on similar soil, (see page 58 of the Supplement) has given very good returns; manure alone has not been very effective, but where a combination of either limestone and manure or limestone and crop

residues was used, very good increases in crop yields have resulted. This soil is so low in nitrogen that a rotation containing a liberal proportion of legumes should be adopted and the legumes should be used very largely for soil improvement. After the nitrogen deficiency has been satisfied in part, the use of 125 pounds of steamed bone meal or 250 pounds of acid phosphate per acre for wheat or rye, might prove profitable. A considerable proportion of this type is now in timber and this use of it should be encouraged.

Fine Dune Sand (486)

Fine Dune Sand occurs in a very limited area in the southwest corner of Crane Creek Township, Township 20 North, Range 7 West, and covers an area of .63 square mile, or .11 percent of the area of the county. It has the typical dune topography and there is no question as to its wind origin.

The surface, to a depth of about 8 inches, is a yellow or brownish yellow fine sand, which is very low in organic matter. No distinct subsurface and subsoil development is discernible, the only change with increasing depth being a gradual disappearance of the brownish tint which is frequently present in the surface.

Management.—The type is very low in nitrogen, phosphorus and sulfur. While this is a more productive soil than Dune Sand, it should be treated in the manner recommended for that type.

Gravelly Loam (290)

Gravelly Loam occurs in four small areas, one just east of Natrona, two near San Jose, and a fourth in Section 7 of Salt Creek Township, Township 20 North, Range 6 West. These represent gravel kames or hills that were deposited by the glacier. They have very little agricultural value, but the gravel may be used in the building of roads.

(b) UPLAND TIMBER SOILS

The upland timber soils occur as irregular zones along streams and on or near somewhat steep morainal ridges. They are characterized by a yellowish gray color, due to their low organic-matter content. The deficiency of organic matter has been caused by the long-continued growth of forest trees. After the forest invaded the prairies, two effects were produced: first, the shade from the trees prevented the growth of prairie grasses, the roots of which are mainly responsible for the large organic-matter content in prairie soils; second, the trees themselves added very little organic matter to the soil, for the leaves and branches either decayed completely or were burned by forest fires. Furthermore, the organic matter that had been produced by the prairie grasses became gradually dissipated during the occupation of the land by the trees. As a result, the organic-matter content of the upland timber soils has been reduced until it is decidedly lower than that of the adjacent prairie land. Several generations of trees were necessary to produce the present condition of the soil.

The upland timber soils of Mason county occupy altogether about 2½ percent of the area of the county.

Yellow Fine Sandy Silt Loam (845)

Yellow Fine Sandy Silt Loam occurs on the upland near the bottom land of Salt Creek. It was formed from fine sandy material which was blown up out of the adjacent bottom land. Owing to the original dune-like character, and the erosion which has taken place, this type is very rough in topography. It covers an area of 5.46 square miles, or .99 percent of the area of the county.

The surface, to a depth of 7 to 9 inches, is a yellowish brown to light brown, fine sandy loam, which is low in organic matter. The subsurface and subsoil differ but little from the surface. The color is yellow and in places a slightly clayey sandy silt loam is found at a depth of 30 to 36 inches, indicating the beginning of true subsoil development.

Management.—The type is low in organic matter, and the growing of legumes and the turning under of residues are very necessary in order to increase the nitrogen and organic-matter content. The soil is usually acid and requires the application of about 2 tons of limestone per acre to grow sweet clover. Carbonates are usually found at a depth of 30 or 40 inches. The type erodes very badly because of the incoherent, fine sandy material that is nearly always found at a depth of 38 to 45 inches. The water-fall form of erosion is very common. This form of erosion is very difficult to control. Probably the best method of control is by means of straw dams made by putting in a double barb wire fence about four feet apart and filling in between with straw, as explained on page 13. Surface washing is not a serious matter on this type, and can be controlled by the ordinary means of incorporating organic matter, growing cover crops, and using care in plowing so as not to have dead furrows extending up and down the hill. If this soil is cropped, it should receive the same management as Dune Sand; however, it is recommended that most of this land be used for pasture.

Yellow-Gray Fine Sandy Silt Loam (844)

Yellow-Gray Fine Sandy Silt Loam covers an area of 1.96 square miles, or .35 percent of the area of the county. It is found in the same region as the Yellow Fine Sandy Silt Loam, but a distinction is made because of the more rolling topography of the latter type.

The surface soil, which is 7 to 9 inches in depth, is a grayish yellow fine sandy loam, low in organic matter. The subsurface is 6 to 12 inches in thickness. It is a yellow or slightly grayish yellow fine sandy loam. The subsoil is usually a yellow clayey silt.

Management.—This type varies widely in acidity. In some places all strata are acid, while in others no acidity is found and no carbonates occur within 40 inches of the surface. In still other places, carbonates are found at a depth of 30 to 40 inches. This soil is low in nitrogen, sulfur, and phosphorus A comprehensive plan for the management of this type should include: first, the application of limestone if needed and in the amounts needed as shown by detailed tests (see page 39 of the Appendix); second, the growing of clovers, particularly sweet clover, and using them largely for soil improvement; third, the plowing in of crop residues, corn stalks directly, and the straws preferably

in the form of manure; and fourth, the application of an available phosphate, either steamed bone meal or acid phosphate, immediately before seeding wheat. It is possible that after the foregoing treatment has been applied, the addition of about 100 pounds per acre of a potash salt for corn would be profitable. If acid phosphate is used, it should be applied at the rate of about 250 pounds per acre, while if steamed bone meal is used, it should be applied at the rate of about 125 pounds per acre.

Yellow Sandy Loam (465, 865)

Yellow Sandy Loam is not an important type because of its limited extent and low agricultural value. There are several isolated areas along the edge of the terrace and also along the bluffs of the Sangamon river and Salt creek. The exposure of sand in the latter place is due to erosion, while in the former it is due to the action of the wind. The total area covered by this type is 4.55 square miles, or .82 percent of the area of the county.

The surface is a yellow sandy loam which is very low in organic matter. There is little change with depth, either in texture or color.

Management.—The more rolling portions of the type should be kept in permanent pasture or timber, as they have very little agricultural value and will be very rapidly ruined by erosion if an attempt is made to farm them.

Yellow-Gray Sandy Loam (464)

Yellow-Gray Sandy Loam is undulating in topography and its distribution is similar to that of the preceding type. It covers an area of 1.88 square miles, or .34 percent of the area of the county.

The surface soil, which is about 7 inches in depth, is a grayish yellow sandy loam. It is low in organic matter. The subsurface is a yellow sandy loam, while the subsoil varies from a silty sand to almost pure sand.

Management.—This type is acid, tho the degree of acidity varies from slight to medium. It is a poorer agricultural soil than Yellow-Gray Fine Sandy Silt Loam (844), but the same recommendations apply that were made for the management of that type.

Yellow-Gray Silt Loam (434)

Yellow-Gray Silt Loam occurs along Prairie creek in the southeastern part of the county and covers only .19 square mile, or 122 acres.

The surface soil, which is about 8 inches in depth, is a grayish yellow silt loam, low in organic matter. The subsurface is a yellowish gray silt loam. The subsoil, which is a compact but not plastic, mottled, yellow silty clay loam, is found at a depth of 16 to 18 inches.

Management.—This type requires the same treatment recommended for Yellow-Gray Fine Sandy Silt Loam (844).

(c) TERRACE SOILS

Terrace soils are formed on terraces or old fills in valleys. The terraces owe their formation generally to the deposition of material from overloaded streams which became greatly enlarged and which flooded the valleys during the melting

of the glaciers. Sometimes these valleys were filled almost to the height of the upland. Later the streams cut down thru the fills and developed new bottom lands, or flood plains, at lower levels, leaving part of the old fills as terraces. The lowest and most recently formed bottom land is called first bottom. The higher land no longer flooded (or very rarely, at most) is generally designated as second bottom or terrace. Finer material later deposited on the sand and gravel of the fill constitutes the mineral portion of the soil. About two-thirds of the area of Mason county is covered by soils of the terrace group.

Brown Sandy Loam (1560)

Brown Sandy Loam, Terrace, is one of the most widely distributed types of the county. It occurs thruout the terrace area. In the more swampy parts of this area, the type occupies the higher places, while in the more sandy regions it is found in the low and more poorly drained places. In the latter case, it is mixed with large irregular areas of Dune Sand. The type covers an area of 126.82 square miles, or 22.89 percent of the area of the county.

The surface soil, which is 7 to 8 inches in depth, is a brown sandy loam low in organic matter. The proportion of sand in the surface soil varies rather widely so that this stratum varies from a sand to a loam. The subsurface is 4 to 16 inches in thickness and varies from a yellowish or grayish brown sand to a yellowish or grayish brown sandy loam. The subsoil varies from a yellow silty sand to a yellow sand. In some areas, as in Townships 22 and 23 North, Range 6 West, the subsoil is heavier than in the more sandy regions.

An interesting variation of the type is found in the southwest part of the county where recent wind action has covered the surface soil to a depth of 3 to 6 inches with sand. Beneath this is a good brown sandy loam stratum, 12 to 20 inches in thickness. Such areas were mapped as Brown Sandy Loam on the basis of productiveness, even tho the surface soil is sand. These areas are very irregular, and it was found impossible to map them satisfactorily.

Management.—This type is acid but varies considerably in degree of acidity. It is an excellent soil for alfalfa after the acidity has been corrected. The organic-matter and nitrogen contents are higher than those of Yellow-Gray Sandy Loam but they are still too low for a productive soil. The pervious character of the soil makes it doubtful whether any form of phosphate could be used at a profit if full use is made of green manures and crop residues. A good soil management program for this type, at least for the present, is the use of limestone in the amounts needed, as indicated by detailed tests; the liberal use of legumes, particularly sweet clover; and good tillage methods.

Dune Sand (1581)

Dune Sand, Terrace, is very widely distributed, but occurs most abundantly within a zone of six to ten miles from the Illinois river. This sand was deposited during the melting of the Wisconsin glaciers when a considerable portion of the present terrace area was under water. The wind re-worked this material, and the formation of the dune areas resulted. Dune Sand, Terrace, covers an area of 113.81 square miles, or 20.54 percent of the area of the county. At one time

a considerable part of this dune area was covered with timber which varied considerably in size of trees and in density of stand. In some cases scattering trees only of black oak occurred, while in others heavy forests of white and red oak were found. It was impossible to make separations of the prairie and timber sand, because there is such a small difference in the organic-matter content between the two, and where the forests have been removed, there is no other basis upon which the separation could be made. The topography of the area varies widely. Some of the dunes are 75 to 100 feet in height, while others may be only 5 or 10 feet. In still other places the area is almost level.

The surface soil is a brownish yellow loamy sand, of medium texture. This same material extends to well below 40 inches in depth with no change except that the color changes to yellow at a depth of about 8 inches. The organic-matter content of this type is very low.

Management.—The recommendations made for the management of Dune Sand of the upland apply equally well to the terrace Dune Sand altho the latter is much more subject to drifting because it occurs in larger areas and the sand particles are somewhat coarser.

To prevent the movement of sand by the wind, it is necessary to have wind breaks, to keep the soil covered with vegetation, or to incorporate organic matter. The latter two methods are really the only practical ways of preventing drifting. Every means should be used for increasing the organic-matter content and for keeping a cover crop on the soil during the larger part of the year. Small grains are better adapted to accomplish this than corn. The plants that are best adapted to sand dunes are legumes, which, to a very large extent, are independent of the nitrogen in the soil. It is interesting to note that a few legumes have adapted themselves to the sand to a remarkable degree. The common sensitive plant (Cassia chameachrista) is found growing in abundance, and many of the abandoned sand fields are being invaded by this plant. It makes a very luxuriant growth. The climbing wild bean (Strophostyles panciflora) is another legume that is growing very abundantly on sand areas. It reseeds itself without any difficulty, and wheat or rye fields are soon covered with a growth of this plant after the crop has been removed. In some cases, at least a ton to the acre is produced. It would seem that this plant might well be distributed over all of the sand areas, especially those that are likely to drift.

In this county there would be very little drifting of these sandy areas if they were left in their natural state. In many places the native vegetation has been destroyed by pasturing too closely or by cropping, thus giving the wind an opportunity to do its work. This results in the formation of "blow-outs," which are small areas from which the surface sand has been blown. The action of the wind may result in the ruin of the land if some protection is not applied. Wind erosion on this soil is as bad as water erosion on other soils. Sand possesses very little cohesion, and is therefore moved quite readily by the wind; but when organic matter is added, this acts as a feeble, yet sufficiently strong, binder to hold the particles together so that drifting is greatly lessened or entirely eliminated.

The cowpea and, to a less extent, the soybean are well adapted to growing on sand. They furnish a large amount of organic matter to hold the sand and

the necessary nitrogen for growing other crops if the crop is plowed down. Where wheat or rye is grown, the drill, with beans or peas, should follow the binder. Normally they will make sufficient growth to add a considerable supply of organic matter and protect the soil during the winter. If the land is reseeded to wheat, the cowpeas may well be allowed to stand and the wheat seeded in them, leaving the vines to hold the sand during the winter. In the growing of a corn crop on sandy land, the lower blades usually die prematurely. This is commonly called "firing" and is attributed to a lack of moisture. While a deficiency of moisture may be responsible to a certain extent, the trouble is oftener due to a lack of the element nitrogen. A liberal supply of organic matter, especially that from legumes, will greatly lessen or entirely prevent "firing."

In the management of a crop on sandy land, cultivation should be practiced no more than is necessary, and should be as shallow as possible. Sand is naturally well adapted to conserve moisture, and there is no necessity for any more cultivation than is necessary to kill the weeds. Some farmers in Michigan never cultivate their corn crop on sand soil, but instead cut out what few weeds there are with a hoe, and they succeed in raising larger crops than where cultivation is practiced.

Black Sandy Loam (1561)

Black Sandy Loam occurs principally in the low, broad valley which probably once formed the course of Mackinaw river thru the county. There may be very silght undulations. The type covers an area of 39.13 square miles, or 7.06 percent of the area of the county.

The surface soil, which is about 8 inches deep, is predominantly a black sandy loam. It varies, however, from a peaty loam to a brown sandy loam, and occasional small patches occur in which the surface is a clay loam. The type normally contains sufficient clay to give it some plasticity when the moisture content is right. It is well supplied with organic matter, much of which, however, is in an advanced or resistant stage of decay. The subsurface consists of a stratum 6 to 12 inches in thickness. It is usually a drab or brownish drab, heavy, sandy loam or sandy clay loam. The subsoil varies rather widely, but usually consists of a clayey sand or a sandy clay, mottled yellowish drab in color and somewhat pervious.

Management.—In the management of this type, drainage is the first consideration, since it is naturally very poorly drained, but with a good outlet and a sufficient number of dredges, this land may be entirely reclaimed so far as removing the excess of water is concerned. Alkali is probably more abundant in this type than any other in the county. It is usually indicated by the presence of shells, altho alkali is frequently found where shells do not exist. On the very bad spots corn frequently will not grow at all, in other cases it will make a low bushy growth, while in still others, it will reach full height but will produce no ears. Salts of potassium applied to these spots at the rate of 100 to 200 pounds per acre will usually overcome the effect of the alkali. Stable manure may be used effectively, and sweet clover turned under will accomplish a great deal toward overcoming the injurious effect. Sweet clover is one of the best crops to grow on alkali.

Where alkali does not exist, ordinary good cultivation with a rotation of crops is about all that is necessary. The soil usually contains a large supply of limestone, but in some areas it is beginning to be slightly acid, and applications of limestone may be necessary in a few years to get best results with legumes. Limestone, however, should not be applied to the alkali spots, as this will have a tendency to intensify the effect of alkali. Crop residues should be returned to the soil to maintain the supply of organic matter and nitrogen.

Brown-Gray Sandy Loam On Tight Clay (1568)

Brown-Gray Sandy Loam On Tight Clay occurs mostly in the center of the county, and usually in the broad valleys at the edge of higher land. Its formation is probably associated with seepage and a high water table. The type covers 30.02 square miles, or 5.42 percent of the area of the county.

The surface soil, which is about 8 inches deep, is predominantly a brown sandy loam. It varies from a silt loam to a sand, but these extremes occupy areas which are too small to show on the map. The color of the surface soil is not uniform, varying from a grayish brown to a gray. The latter color occurs in irregular spots distributed over the areas, and is especially noticeable when the soil has become dry following a rain. This soil is low in organic matter. The subsurface is 9 to 12 inches in thickness. The upper part is brownish gray in color, somewhat similar to the surface, but passes at a varying depth into a gray sandy silt containing little organic matter. The subsurface, at a depth of 17 to 20 inches, passes very abruptly into the subsoil, which is a plastic, impervious, mottled yellow clay. The thickness of this clay layer varies from 8 to 20 inches or more. Usually a coarse sand is found beneath it. A few areas have been found in which this impervious clay is more than 30 inches in depth, but usually it occurs at about 20 inches. The impervious character of this subsoil causes poor drainage.

Management.—The surface and subsurface of this type are, so far as is known, always strongly acid; the subsoil is usually strongly acid, tho not always so. An application of about 4 tons of limestone per acre is necessary for sweet clover. The soil is low in organic matter and consequently in nitrogen. A rotation should be adopted and so handled that these deficiencies will be taken care of. Sweet clover is an excellent crop to grow on this soil for the purpose of increasing the supply of nitrogenous organic matter. The phosphorus content of this type is low. There is no experimental evidence available as to whether any form of phosphate can be used at a profit. Rock phosphate has been used on Brown-Gray Silt Loam On Tight Clay on the Pana field with but little effect. It is reasonable to suppose that an available phosphate applied for wheat, as recommended in the case of Dune Sand (page 23), would prove profitable Poor drainage is the fundamental limiting factor in crop production on this type of soil. At the present time, no better method of improving this condition is known than by means of furrows and open ditches.

Black Clay Loam (1520)

Black Clay Loam, Terrace, is distributed principally in the eastern third of the county and is found mostly on the east side of the old Mackinaw valley

now occupied by Crane creek. It covers 9.08 square miles, or 1.64 percent of the area of the county.

The surface soil, which is about 8 inches in depth, is usually a black clay loam, granular when dry and plastic when wet. It is high in organic matter. Small areas occur in which the surface is a sandy clay loam and others in which the surface is a peaty loam. The organic-matter content is always high. The subsurface soil is about 11 inches in thickness and is a drabbish, black, waxy clay loam. It passes into a drab or olive colored, mottled subsoil at about 18 inches. The subsurface and subsoil do not vary so much as the surface in their physical composition, but they are frequently found containing an appreciable amount of sand.

Management.—Drainage is the most important consideration in the management of this type, and with a good outlet, this may easily be provided, since all strata are pervious to water, and tile drains work well. All the elements of plant food are abundant. This fact, together with the fact that all strata nearly always contain an abundance of limestone, makes this a very desirable soil, even tho it is a hard soil to work. Alkali patches are numerous, and of course decrease the value of the land wherever they occur. The effect of the alkali may be overcome by the use of potassium salts, stable manure, or green manures.

Black Silt Loam (1525)

Black Silt Loam, Terrace, occurs in the same region as Black Sandy Loam. It covers an area of 10.56 square miles, or 1.91 percent of the area of the county.

The surface soil is about 9 inches deep. It is a black silt loam with small areas varying from a black clay loam to a brown silt loam. In small local patches, Black Sandy Loam occurs, but these are not large enough to be shown on the map. Altho this type is well supplied with organic matter, the amount of fresh, readily decomposable organic matter is frequently too low. The subsurface soil is 6 to 10 inches in thickness, and is a drabbish, black clayey silt to clay loam. The subsoil is a mottled, olive drab or dull yellow sandy clay.

Management.—The necessity of drainage is about the same for this type as for Black Clay Loam and Black Sandy Loam. Since the strata are pervious, drainage is easily effected if an adequate outlet can be obtained. This type is well supplied with both nitrogen and phosphorus, but a good rotation should be practiced and residues returned to the soil in order to maintain the supply of nitrogen and keep the soil in good physical condition. All strata are rich in limestone. Alkali spots occur very frequently and in some cases this becomes a very serious objection to the soil. Alkali injury may be largely overcome, however, by the use of potassium salts, sweet clover, or manure.

Brown Silt Loam Over Sand or Gravel (1527)

Brown Silt Loam Over Sand Or Gravel occurs principally along the eastern edge of the old Mackinaw valley in a strip one to two miles wide A great many smaller, isolated areas occur, principally in this region. The type is associated with Brown-Gray Silt Loam On Tight Clay (1528). It covers an area of 15.76 square miles, or 2.84 percent of the area of the county.

The surface soil, which is about 8 inches deep, is a brown silt loam. Small patches frequently occur which are sufficiently sandy to be classified as a sandy loam. The subsurface soil is 6 to 10 inches in thickness and is a brown silt loam. The subsurface becomes lighter in color with increasing depth, and also varies somewhat in texture as does the surface soil. The subsoil is a slightly mottled, brownish yellow sandy silt, and in some areas sand occurs at about 36 inches in depth.

Management.—This type, for the most part, is becoming slightly acid. An application of about 2 tons of limestone per acre is probably sufficient to grow sweet clover or alfalfa on any portion of the area. All the elements of plant food and also organic matter are present in fair abundance. The soil is pervious and unless the stratified sand or gravel is too near the surface, roots penetrate to good depths. The type generally is not drouthy, as is frequently the case with terrace soils, because of the considerable depth to the sand or gravel. The natural underdrainage is good. In the management of the type, provision should be made for systematic addition of nitrogenous organic matter. Sweet clover is suggested as an excellent crop for this purpose and good use may be made of alfalfa as a biennial in the regular rotation since this is a good alfalfa soil.

Yellow-Gray Sandy Loam On Sand (1564.2)

Yellow-Gray Sandy Loam On Sand occurs in isolated areas thruout the sandy region in the western part of the county. These areas generally occupy the lower portions and have all been timbered. The area covered by this type is 11.95 square miles, or 2.16 percent of the area of the county.

The surface is about 7 inches deep and is a grayish yellow sandy loam which is very low in organic matter. The subsurface is a yellow sandy loam about 13 inches in thickness. It passes into a yellow sand subsoil at 18 to 30 inches in depth.

Management.—This type is acid and is low in the elements of plant food. Nitrogen is the limiting factor and before any progress can be made in increasing the productivity of the type the nitrogen and organic-matter contents must be increased. The first step in doing this is to apply 3 or 4 tons of limestone per acre to be followed by sweet clover. The sweet clover should be used primarily for soil improvement. After the nitrogen content of the soil has been increased, the use of acid phosphate or bone meal for wheat or rye, as recommended for Dune Sand (page 58), may prove profitable.

Brown-Gray Silt Loam On Tight Clay (1528)

Brown-Gray Silt Loam On Tight Clay occurs in the old Mackinaw valley and covers 4.19 square miles, or .76 percent of the total area of the county.

The surface soil is about 7 inches deep and is a grayish brown silt loam. It is rather low in organic matter. The subsurface soil is 8 to 12 inches in thickness. The upper few inches of this stratum are brownish gray silt loam, which changes abruptly into a light gray silt loam. This stratum is 3 to 10 inches in thickness. The subsoil is a mottled yellowish, plastic, impervious clay. It is 8 to 20 inches thick. Beneath this is found a stratum of friable silt loam or

fine sandy loam. Frequently sand is encountered in the subsoil at a depth of 36 to 40 inches. The impervious clay prevents the water from moving downward. The water table is sometimes so high that good drainage would not result even if the water could get thru the impervious stratum.

Management.—The type is acid. The application of about 3 tons of limestone per acre should make the growth of sweet clover possible. The growing of legumes is very necessary to overcome the deficiency in nitrogen and organic matter. The phosphorus content is low, but phosphates cannot be used at a profit before the nitrogen need has been satisfied and possibly not even then, because of the poor physical condition of this soil resulting from the presence of the impervious subsoil.

Fine Dune Sand (1586)

Altho Fine Dune Sand is found on the terrace, it is a continuation of the same type found in the upland, and practically all occurs in Crane Creek Township, Township 20 North, Range 7 West. The type as found on the terrace covers 2.78 square miles, or .50 percent of the area of the county. The type description and recommendations for management given for Fine Dune Sand of the upland (486) apply equally well to this terrace type.

Yellow-Gray Silt Loam (1534)

Yellow-Gray Silt Loam, Terrace, is found along Salt creek. It occurs on a terrace that is about 25 to 30 feet above the present bottom land, and it covers an area of 1.26 square miles, or .23 percent of the area of the county.

The surface soil is a grayish yellow silt loam, which is low in organic matter. At a depth of 7 to 8 inches the color changes to yellow and extends without change thru the depth of the section described, 40 inches. The subsurface soil is a silt loam, and the subsoil differs from this but little.

Management.—This type is well drained but is deficient in nitrogen and organic matter. Before sweet clover or alfalfa can be grown on it, 3 or 4 tons of limestone per acre must be applied. In order to increase the nitrogen content of the soil, crop residues, manure, and legumes must be plowed under. A rotation in which a legume is grown every 4 years at least should be practiced, and if these nitrogen-gathering crops can be grown more frequently, it would be very desirable.

(d) SWAMP AND BOTTOM-LAND SOILS

In the group designated as swamp and bottom-land soils are included the bottom lands or flood plains along streams, the swamps, the poorly drained lowlands, and also all peats and mucks, whether on upland or terrace. Much of the soil is of alluvial formation, and the land is largely subject to overflow.

Deep Brown Silt Loam (1426)

Deep Brown Silt Loam occurs only along Sangamon river and Salt creek, and represents an excellent type of soil. It covers an area of 16.21 square miles, or 2.93 percent of the area of the county.

The soil to a depth of about 20 inches or more is a brown silt loam varying toward a clay loam on the one hand and a sandy loam on the other. It is fairly well supplied with organic matter. At a depth of 20 to 30 inches the color becomes light brown or yellowish brown. No distinct strata have been formed in this type because of its recent formation.

Management.—This type is well supplied with the elements of plant food and the soil is in very fair physical condition. Organic matter in the form of crop residues and legumes should, however, be turned under to maintain the supply. The soil is becoming acid, owing to the construction of a levee which prevents overflow, and it will soon be necessary to apply limestone.

Mixed Loam (1454)

Mixed Loam occurs along streams and is found usually where there is considerable overflow accompanied by rather rapid currents of water, so that much sand is deposited. The soil areas are so small and so badly mixed that it is impossible to separate them into distinct types, and even if this were done, the next flood would probably change them. The total area covered by this type is 44.24 square miles, or 7.98 percent of the area of the county.

The surface soil varies in depth and in texture from a sandy loam to a clay loam, and in color from a light brown to a black. The variation is as great, or greater, below a depth of 8 or 10 inches than is found in the surface.

Management.—This type is productive and would be much more valuable were it not for periods of overflow. In some places the soil is becoming acid, while in others abundance of limestone is found. It is fairly well supplied with the element nitrogen and if a rotation is practiced with a legume every four or five years, and the residues turned under, the nitrogen content will be maintained. The soil generally is well supplied with phosphorus.

Drab Clay Loam (1421)

Drab Clay Loam occurs in the bottom land of Salt creek and Sangamon river, and covers an area of 7.30 square miles, or 1.32 percent of the area of the county.

The surface soil, which is about 8 inches in depth, is a drab to a very dark drab clay loam, fairly well supplied with organic matter.

The subsurface is about 14 inches in thickness, and consists of a drab clay loam that usually contains brown blotches, which are due to iron oxide. The subsoil is a drab clay loam.

Management.—This is a very good soil, but it is becoming acid. Applications of about 2 tons of limestone per acre should be made, and legume crops grown in order to maintain the nitrogen and keep the soil in good tilth. If the organic matter becomes deficient, the soil will become difficult to work. Therefore a regular rotation in which the legumes, residues, and manure are turned under should be practiced. The soil is well supplied with phosphorus.

Deep Peat (1401)

Deap Peat is found in various parts of the county, the largest single area occurring near Manito. Other areas are found along the edge of the bottom land of the Sangamon river and Salt creek. The total area covered by this type is 3.57 square miles, or .64 percent of the area of the county.

This soil is a brown to black peat containing about 76 percent of organic matter. It varies to some extent locally, having a perceptible amount of sand in places. It varies in depth, but rarely exceeds 10 feet.

Management.—The first requirement of this type is drainage. The best form of drainage, especially at first, is the open ditch. Peat does not furnish a very good bed for tile, because it allows them very soon to get out of line, when they almost entirely cease to do their work. However, after peat has been drained for some time and it has become more compact and greater decomposition has taken place, tile may be used, but they should always be of fair size in order to minimize the danger of wrong alignment. It has been suggested that the tile might be laid on boards, and this method probably could be used to advantage in many areas.

Where thoro drainage can be provided either by open ditches or by laying tile deep enough to secure a solid bed for them, very marked improvement can be made in the productive power of deep peat by the use of potassium, which is by far the most deficient element. Very striking results from the use of potassium were obtained in field experiments conducted on peat land near Manito, an account of which will be found in the Supplement, page 60.

Medium Peat On Clay (1402)

Medium Peat On Clay is usually associated with Deep Peat. In this county it covers an area of .84 square mile, or .15 percent of the area of the county.

This soil has the same characteristics as Deep Peat, excepting that at a depth of 12 to 30 inches drab clay is found.

Management.—This type is usually deficient in potassium, and the same treatment should be applied as in the case of Deep Peat.

Peaty Loam On Sand (1410.2)

Peaty Loam On Sand occurs where the accumulation of organic material and sand, which has either been blown or washed in, has taken place at the same time. This gives a mixture of the sand and organic matter and if the organic matter forms more than 15 percent and less than 35 percent of the soil, it is classified as peaty loam. This type covers 2.96 square miles, or .53 percent of the area of the county.

The surface soil, which is about 10 inches deep, is a mixture of sand and organic matter, called a peaty loam, and contains about 16.6 percent of organic matter. The subsurface is 6 to 12 inches in thickness and contains about one-half as much organic matter, in percentage, as the surface. Sand is found at varying depths, but usually between 14 and 20 inches below the surface.

Management.—Peaty Loam On Sand varies widely, but in general it responds to potassium. While the sand may contain considerable amounts of potassium,

yet on account of the size of the sand particles, it is very slowly available, and as a general rule, applications of 100 to 200 pounds of potassium salts will give profitable results. Alkali may be present in this type, but its harmful effect may be corrected by the potassium treatment. An account of field experiments at Tampico, Illinois, is given in the Supplement, page 61.

Clayey Muck (1413)

Clayey Muck was formed where clay and silt were deposited in a swamp in which organic matter was accumulating, thus giving rise to a mixture of these three materials. It covers an area of .26 square mile, or 166 acres. It is a black material, very high in organic matter, granular when dry, and plastic when wet. At a depth of 20 to 30 inches, drab clay is found.

Management.—Drainage is the first requirement of this type, and if ordinary good cultivation is practiced, good results will follow.

Yellow Fine Sandy Loam (1475)

Yellow Fine Sandy Loam occurs along the bluff of Salt creek and is produced by the outwash from streams of the deep loess area. These areas are nearly always in the nature of alluvial fans. The total area covered by the type is 1.18 square miles, or .21 percent of the area of the county.

This soil is a yellow fine sandy loam with very little change to the depth examined (40 inches), except that the subsoil is higher in organic matter than the surface. This peculiar condition is explained by the fact that the recent deposition of mineral material has been so rapid that but little organic matter has accumulated.

Management.—The type contains an abundance of limestone but means should be taken to increase the amount of organic matter and nitrogen.

Brown Sandy Loam (1460)

Brown Sandy Loam, Bottom Land, occurs along the rivers of the south side of the county and on small higher areas in the bottom land or on those areas near the bluff that have received the sandy wash from the upland. The total area of this type is 3.48 square miles, or .63 percent of the area of the county.

The surface soil, which is about 8 inches deep, is a brown sandy loam fairly high in organic matter. The sand content varies rather widely. The subsurface is a light brown sandy loam, 6 to 12 inches in thickness. The subsoil is usually sandier than either the surface or subsurface, and in some cases may pass into sand.

Management.—The type requires the same treatment as Brown Sandy Loam, Upland (see page 13).

Alluvial Sand (1480)

In a few cases the streams along the bluff carry large amounts of sand during times of flood, and this is distributed as an alluvial fan where the stream leaves its gorge and spreads out into the bottom land. This forms a sand deposit. The area covered by Alluvial Sand is only 160 acres. It is of low productivity until it becomes mixed with organic matter.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to intelligently interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification used.

The type is the unit of classification and each type has definite characteristics. In establishing types, the following factors are taken into account: the character of the horizons composing the soil as to depth and thickness, physical composition, structure, organic-matter content, color, reaction, and carbonate content; the topography; the native vegetation; and the geological origin of the soil.[1]

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made whenever the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

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[1] Since some of the terms used in designating the factors which are taken into account in establishing soil types are technical in nature, the following explanations are introduced:

Horizon. A layer or stratum of soil which differs discernibly from those adjacent in color, texture, structure, chemical composition, or a combination of these characteristics, is called an horizon.

Depth and Thickness. The horizons or layers which make up the soil profile vary in depth and thickness. These variations are distinguishing features in the separation of soils into types.

Physical Composition. The physical composition, sometimes referred to as "texture," is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents: clay, silt, fine sand, sand, gravel, stones, and organic material.

Structure. The term "structure" has reference to the aggregation of particles within the soil mass and carries such qualifying terms as open, granular, compact.

Organic-Matter Content. The organic matter of soil is derived largely from plant tissue and it exists in a more or less advanced stage of decomposition. Organic matter constitutes the predominating constituent in certain soils of swampy formation.

Color. Color is determined to a large extent by the proportion of organic matter, but at the same time it is modified by the mineral constituents, especially by iron compounds.

Reaction. The term "reaction" refers to the chemical state of the soil with respect to acid or alkaline condition. It also involves the idea of degree as strongly acid or strongly alkaline.

Carbonate Content. The carbonate content has reference to the calcium carbonate (limestone) present, which in some cases may be associated with magnesium or other carbonates. The depth at which carbonates are found may become a very important factor in determining the soil type.

Topography. Topography has reference to the lay of the land, as level, rolling, hilly, etc.

Native Vegetation. The vegetation or plant growth before being disturbed by man, as prairie grasses and forest trees, is a feature frequently recognized in determining soil types.

Geological Origin. Geological origin involves the idea of character of rock materials composing the soil as well as the method of formation of the soil.

Classifying Soil Types.—In the system of classification used, the types fall first into four general groups based upon their geological relationships; namely, upland, terrace, swamp and bottom land, and residual. These groups may be subdivided into prairie soils and timber soils, altho as a matter of fact this subdivision is applied in the main only to the upland group. These terms are all explained in the foregoing part of the report in connection with the description of the particular soil types.

Naming and Numbering Soil Types.—In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a more or less definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise type names which are adequately descriptive, because the profile of mature soils is usually made up of four or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "on," and when its depth exceeds 30 inches, by the word "over"; for example, Brown Silt Loam On Gravel, and Brown Silt Loam Over Gravel.

As a further step in systematizing the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been assigned an index number. The names of the areas together with their general location and their corresponding index numbers are given in the following list.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* comprizing three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciations
300 *Lower Illinoisan glaciation,* covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* found in the older or Illinoisan glaciation
1400 *Late river-bottom and swamp lands,* those of the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan

For further information regarding these geological areas the reader is referred to the general map published in Bulletins 123 and 193.

Another set of index numbers is assigned to the classes of soils as based upon physical composition. The following list contains the names of these classes with their corresponding index numbers.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy Loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the balance of the number designates the type. To illustrate: the number 1126 means Brown Silt Loam in the early Wisconsin glaciation, 434 means Yellow-Gray Silt Loam of the middle Illinoisan glaciation. These numbers are especially useful in designating very small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports in connection with the maps.

SOIL SURVEY METHODS

Mapping of Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. The field work is done by parties of two to four men each. The field season extends from early in April to Thanksgiving. During the winter months the men are engaged in preparing a copy of the soil map to be sent to the lithographer, a copy for the use of the farm adviser until the printed map is available, and a third copy for use in the office in order to preserve the original official map in good condition.

An accurate base map for field use is necessary for soil mapping. These maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as the basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil type boundaries, together with the streams, roads, railroads, canals, town sites, and rock and gravel quarries are placed in their proper location upon the map while the mapper is on the area. With the rapid development of road improvement during the past few years, it is almost inevitable that some recently established roads will not appear on the published soil map. Similarly, changes in other artificial features will occasionally occur in the interim between the preparation of the map and its publication. The detail or minimum size of areas which are shown on the map varies somewhat, but in general a soil type if less than five acres in extent is not shown.

A soil auger is carried by each man with which he can examine the soil to a depth of 40 inches. An extension for making the auger 80 inches long is taken

by each party, so that the deeper subsoil may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by a speedometer or other measuring device, while distances in the field away from the roads are measured by pacing.

Sampling for Analysis—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. The samples for this purpose are usually taken in three depths; namely, 0 to 6⅔ inches, 6⅔ to 20 inches, and 20 to 40 inches, as explained in connection with the discussion of the analytical data on page 6.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. A fact of equal importance, not so generally recognized, is that they also differ in other characteristics such as response to fertilizer treatment and to management.

The soil is a dynamic, ever-changing, exceedingly complex substance made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, the soil cannot be considered as a reservoir into which a given quantity of an element or elements of plant food can be poured with the assurance that it will respond with a given increase in crop yield. In a similar manner it cannot be expected to respond with perfect uniformity to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance favorable for the growth of the higher plants and of the beneficial microorganisms. Good soil management under humid conditions involves the adoption of those tillage, cropping, and fertilizer treatment methods which will result in profitable and permanent crop production on the soil type concerned.

The following paragraphs are intended to state in a brief way some of the principles of soil management and treatment which are fundamental to profitable and continued productivity.

CROP REQUIREMENTS WITH RESPECT TO PLANT-FOOD MATERIALS

Ten different elements of plant food are essential for the growth and formation of every plant. These elements are: *carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, magnesium, calcium, and iron.* Some seasons in central Illinois are sufficiently favorable to allow the production of at least 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. When such crops, growing under favorable climatic and cultural conditions and uninjured by disease or insect pests, are not produced the failure is due to unfavorable soil conditions, which may result from poor drainage, poor physical condition, or from an actual deficiency in one or more of the elements of plant food.

TABLE A.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce: Kind	Produce: Amount	Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain......	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat, straw.....	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain.......	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover.......	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs........	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain.......	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw........	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed.......	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay.......	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed.....	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay......	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay.......	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1] These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

Table A shows the requirements of some of our most common field crops with respect to the seven plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of any element removed from an acre of land by a crop of a given yield can easily be computed.

PLANT-FOOD SUPPLY

Of the ten elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and seven from the soil. *Nitrogen,* one of these seven elements obtained from the soil by all plants, may also be secured from the air by the class of plants known as legumes, in case the amount liberated from the soil is insufficient; but even these plants, which include only the clovers, peas, beans, and vetches among our common agricultural plants, are dependent upon the soil for the other six elements (phosphorus, potassium, magnesium, calcium, iron, and sulfur), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 420 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor

TABLE B.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	...	...
Sodium nitrate	310	...	...
Ammonium sulfate	400	...	...
Raw bone meal	80	180	...
Steamed bone meal	20	250	...
Raw rock phosphate	...	250	...
Acid phosphate	...	125	...
Potassium chlorid	...	...	850
Potassium sulfate	...	...	850
Kainit	...	...	200
Wood ashes[3] (unleached)	...	10	100

[1] See footnote to Table A.
[2] Young second year's growth ready to plow under as green manure.
[3] Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

of production, then we must look for some outside source of supply. Table B is presented for the purpose of furnishing information regarding the quantity of some of the more important plant-food elements contained in materials most commonly used as sources of supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of plant-food elements actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such elements as calcium and phosphorus, converting them into available forms for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral elements are liberated for

the benefit of the cereal crops which follow in the rotation. Moreover, as an effect of the deep-rooting habit of these legumes, mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and supplies calcium, thus encouraging the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the unavailable organic nitrogen into available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium compounds.

Organic Matter and Biological Action.—Organic matter may be supplied thru animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant-food materials than the 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the ratio of carbon to nitrogen. Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing available phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant-food elements by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant-food materials are concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than

this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter, and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement.

Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands. Remarkable success has been experienced with limestone used in conjunction with sweet clover in the reclamation of abandoned hill land which has been ruined thru erosion.

Amounts to Apply.—If the soil is acid, usually at least 2 tons per acre of ground limestone should be applied as an initial treatment. Continue to apply limestone from time to time according to the requirement of the soil as indicated by the tests described below, or until the most favorable conditions are established for the growth of legumes, using preferably at times magnesian limestone ($CaCO_3MgCO_3$), which contains both calcium and magnesium and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone ($CaCO_3$). On strongly acid soils, or on land being prepared for alfalfa, 4 or 5 tons per acre of ground limestone may well be used for the first application.

How to Ascertain the Need for Limestone.—One of the most reliable indications as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover and alfalfa. These crops do not thrive in acid soils. Their successful growth, therefore, indicates the lack of sufficient acidity in the soil to be harmful. In case of their failure to grow the soil should be tested for acidity as described below. A very valuable test for ascertaining the need of a soil for limestone is found in the potassium thiocyanate test for soil acidity. It is of value to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonate of calcium and magnesium. The natural occurrence of these carbonates in the

soil is sufficient assurance that no limestone is needed, and the acidity test will be negative. On lands which have been treated with limestone, however, the surface soil may give a positive test for carbonates, due to the presence of undecomposed pieces of limestone, and at the same time a positive test for acidity may be secured. Such a result means either that insufficient limestone has been added, or that it has not been in the soil long enough to entirely correct the acidity. In making these tests, it is desirable to examine samples of soil from different depths, since carbonates may be present, even in abundance, below a surface stratum that is acid. Following are the directions for making the tests:

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol (not denatured). When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. In testing, therefore, the sample should be about as dry as when the soil is in good tillable condition. The conditions for a prompt reaction require a temperature that is comfortably warm.

The Hydrochloric Acid Test for Carbonates. Make a shallow cup of a ball of soil and pour into it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence, and indicates that the soil contains limestone or some other carbonate. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen usually costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for plant growth. These are the chemical and the biological fixation of the atmospheric nitrogen. Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of those legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for purposes other than the fixation of atmospheric nitrogen, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen will ever be able to replace the simple method

of obtaining atmospheric nitrogen by growing inoculated legumes in the production of our great grain and forage crops.

It may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpea hay contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of the soil is dependent upon the origin of the soil. The removal of phosphorus by continuous cropping slowly reduces the amount of this element in the soil available for crop use, unless its addition is provided for by natural means, such as overflow, or by agricultural practices, such as the addition of phosphatic fertilizers and rotations in which deep-rooting, leguminous crops are frequently grown.

It should be borne in mind in connection with the application of phosphate, or of any other fertilizing material, to the soil, that no benefit can result until the need for it has become a limiting factor in plant growth. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different materials containing phosphorus which are applied to land as fertilizer. The more important of these are bone meal, acid phosphate, natural raw rock phosphate, and basic slag. Obviously that carrier of phosphorus which gives the most economical returns, as considered from all standpoints, is the most suitable one to use. Altho this matter has been the subject of much discussion and investigation the question still remains unsettled. Probably there is no single carrier of phosphorus that will prove to be the most economical one to use under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

Bone meal, prepared from the bones of animals, appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the

phosphorus, a considerable percentage of nitrogen which adds a useless expense if the material is purchased only for the sake of the phosphorus. As a source of phosphorus, steamed bone meal is preferable to raw bone meal. Steamed bone meal is prepared by extracting most of the nitrogenous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate containing about 10 to 12 percent of the element phosphorus.

Acid phosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. Acid phosphate also contains besides phosphorus, sulfur, which is likewise an element of plant food. The phosphorus in acid phosphate is more readily available for absorption by plants than that of raw rock phosphate. Acid phosphate of good quality should contain 6 percent or more of the element phosphorus.

Rock phosphate, sometimes called floats, is a mineral substance found in vast deposits in certain regions. The phosphorus in this mineral exists chemically as tri-calcium phosphate and a good grade of the rock should contain 12½ percent, or more, of the element phosphorus. The rock should be ground to a powder, fine enough to pass thru a 100-mesh sieve, or even finer.

The relative cheapness of raw rock phosphate, as compared with the treated or acidulated material, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in this form than in the form of acid phosphate, the ratio being, under the market conditions of the past several years, about 4 to 1. That is to say, under these market conditions, a dollar will purchase about four times as much of the element phosphorus in the form of rock phosphate as in the form of acid phosphate, which is an important consideration if one is interested in building up a phosphorus reserve in the soil. As explained above, more very carefully conducted comparisons on various soil types under various cropping systems are needed before definite statements can be given as to which form of phosphate is most economical to use under any given set of conditions.

Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag phosphate is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore it tends to influence the soil reaction.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating the phosphorus from raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using acid phosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount

to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, which are silt loams and clay loams, are well stocked with potassium, altho it exists largely in a slowly soluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be supplied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of common soils are concerned, that, with a few exceptions, the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part, perhaps, because the potassium removed in the crops is mostly returned in the manure if properly cared for, and perhaps in larger part because the decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no plant-food elements of value.

In considering the conservation of potassium on the farm it should be remembered that in average live-stock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in live-stock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by the actual crop requirements for plant food, magnesium and calcium are more limited in some Illinois soils than potassium. But with these elements we must consider also the loss by leaching.

The annual loss of limestone from the soil depends, of course, upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of lime materials from the soil, it is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

Limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur

in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply to conditions in Illinois.

Physical Improvement of Soils

In the management of most soil types, one very important matter, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, slightly retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is undergoing destruction during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, corn stalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and corn stalks should be turned under, and not burned. There is considerable evidence indicating that on some soils undecomposed straw applied in excessive amount may be detrimental. Probably the best practice is to apply the straw as a constituent of well-rotted stable manure. Perhaps no form of organic matter acts more beneficially in producing good tilth than corn stalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of corn stalks is one and one-half times that of a ton of manure, and a ton of dry corn stalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the corn stalks during the winter and often rather late in the spring after the frost is out of the ground. This trampling by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too

late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The effect becomes worse if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including, for the reasons discussed above, a liberal use of legumes. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations, applicable to the corn belt, which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth Year —Wheat (with clover), or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in live-stock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be seeded four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. Or, in some cases, it may become desirable to divide the acreage of small grain and grow in the same year more than one kind. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields on Soil Types Similar to those Occurring in Mason County)

In the earlier reports of this series it was the practice to incorporate in the body of the report the results from certain experiment fields, for the purpose of illustrating the possibilities of improving the soil of various types. The information carried by such data must, naturally, be considered more or less tentative. As the fields grow older new facts develop, which in some instances may call for the modification of former recommendations. It has therefore seemed desirable to separate this experiment field data from the more permanent information of the soil survey, and embody the same in the form of a supplement to the soil report proper, thus providing a convenient arrangement for possible future revisions as further data accumulate.

The University of Illinois has operated altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the summarized results from certain of these fields located on types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, live-stock farming and grain farming.

In the live-stock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as corn stalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It is the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the live-stock system.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a rather definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grain to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, usually 200 pounds of kainit. When kainit was not available, owing to conditions brought on by the World war, potassium carbonate was used. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

TABLE 1.—URBANA FIELD, MORROW PLOTS: BROWN SILT LOAM; PRAIRIE; EARLY WISCONSIN GLACIATION

Annual Crop Yields—Bushels or (tons) per acre.

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
		Corn	Corn	Oats	Corn	Oats	Clover
1879–87	None	....	....	....	....	....	....
1888	None	54.3	49.5	....	....	48.6	....
1889	None	43.2	....	37.4	....	....	(4.04)
1890	None	48.7	54.3	....	....	....	(1.51)
1891	None	28.6	33.2	....	....	....	(1.46)
1892	None	33.1	....	37.2	70.2	....	....
1893	None	21.7	29.6	....	34.1	....	....
1894	None	34.8	....	57.2	....	65.1	....
1895	None	42.2	41.6	....	....	22.2	....
1896	None	62.3	....	34.5	....	....	....
1897	None	40.1	47.0	....	....	....	....
1898	None	18.1	....	....	....	....	....
1899	None	50.1	44.4	....	53.5	....	....
1900	None	48.0	....	41.5	....	....	....
1901	None	23.7	33.7	....	34.3	....	....
1902	None	60.2	....	56.3	....	54.6	....
1903	None	26.0	35.9	....	....	....	(1.11)
1904	None	21.5	....	17.5	55.3	....	....
1904	MLP	17.1	....	25.3	72.7	....	....
1905	None	24.8	50.0	....	....	42.3	....
1905	MLP	31.4	44.9	....	....	50.6	....
1906	None	27.1	....	34.7	....	....	(1.42)[1]
1906	MLP	35.8	....	52.4	....	....	(1.74)[1]
1907	None	29.0	47.8	....	80.5	....	....
1907	MLP	48.7	87.6	....	93.6	....	....
1908	None	13.4	....	32.9	....	40.0	....
1908	MLP	28.0	....	45.0	....	44.4	....
1909	None	26.6	33.0	....	....	....	(.65)[2]
1909	MLP	31.6	64.8	....	....	....	(1.73)[3]
1910	None	35.9	....	33.8	58.6	....	....
1910	MLP	54.6	....	59.4	83.3	....	....
1911	None	21.9	28.6	....	....	20.6	....
1911	MLP	31.5	46.3	....	....	38.0	....
1912	None	43.2	....	55.0	....	....	16.3[1]
1912	MLP	64.2	....	81.0	....	....	20.0[1]
1913	None	19.4	29.2	....	33.8	....	....
1913	MLP	32.0	25.0	....	47.8	....	....
1914	None	31.6	....	33.6	....	39.6	....
1914	MLP	39.4	....	58.2	....	60.4	....
1915	None	40.0	49.0	....	....	....	24.2[1]
1915	MLP	66.0	81.2	....	....	....	27.1[1]
1916	None	11.2	....	37.5	27.8	....	....
1916	MLP	10.8	....	64.7	40.6	....	....
1917	None	40.0	48.4	....	....	68.4	....
1917	MLP	78.0	81.4	....	....	86.9	....
1918	None	13.6	....	27.2	....	....	(2.58)
1918	MLP	32.6	....	59.3	....	....	(4.04)
1919	None	24.0	30.8	....	52.2	....	....
1919	MLP	43.4	66.2	....	70.8	....	....
1920	None	28.2	....	37.2	....	52.2	....
1920	MLP	54.4	....	51.6	....	69.7	....
1921	None	19.8	30.6	....	....	....	(.26)[4]
1921	MLP	42.2	68.4	....	....	....	(1.33)[5]
1922	None	24.6	....	39.3	49.2	....	....
1922	MLP	39.4	....	55.8	65.3	....	....
1923	None	15.0	17.2	....	....	53.4	....
1923	MLP	31.4	46.4	....	....	66.6	....

[1] Soybeans.
[2] In addition to the hay, .64 bushels of seed was harvested.
[3] In addition to the hay, 1.17 bushels of seed were harvested.
[4] In addition to the hay, .53 bushel of seed was harvested.
[5] In addition to the hay, .85 bushel of seed was harvested.

BROWN SILT LOAM

Several experiment fields have been conducted on Brown Silt Loam at various locations in Illinois. Those located at the University have been in operation the longest and they serve well to illustrate the principles involved in the maintenance and improvement of this type of soil.

The Morrow Plots

So far as known the oldest soil experiment field in the United States is located on typical Brown Silt Loam of the early Wisconsin glaciation, on the campus of the University of Illinois. This field was started in 1879 by George E. Morrow, who for many years was Professor of Agriculture, and these plots are known as the Morrow plots.

The Morrow series now consists of three plots divided into halves and the halves are subdivided into quarters. On one plot corn is grown continuously; on the second, corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904. Besides farm manure, phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. At the same time the rate of subsequent application of both forms of phosphorus was reduced to one-fourth the quantity, or to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per year. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre.

Table 1 gives the yearly records of the crop yields from the Morrow plots, and Table 2 presents the results in summarized form.

Summarizing the data from these Morrow plots into two periods with the second period beginning in 1904 when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the untreated continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oats production, while the averages

TABLE 2.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY
Average Annual Yields—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover
		16 crops	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
1888 to 1903	None........	39.7	41.0	44.0	48.0	47.6	(2.03)
		20 crops	*10 crops*	*10 crops*	*7 crops*	*7 crops*	*4 crops*
1904 to 1923	None........	25.5	36.5	34.9	51.1	45.2	(1.23)[1]
	MLP........	40.6	61.2	55.3	67.7	59.5	(2.21)[1]

[1] One crop of soybean hay included.

for the three-year system show an increase in corn yield and decreases in oats and clover. Unfortunately the numbers of crops included in these last averages are too small to warrant positive conclusions.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

The Davenport Plots

Another set of plots on the University campus at Urbana, forming a more extensive series than the Morrow plots, but of more recent origin, are the Davenport plots. Here provision is made for each crop in the rotation to be represented every year. These plots were laid out in 1895, but special soil treatment was not begun until 1901. They now comprize five series of ten plots each, and each series constitutes a "field" in a crop rotation system.

From 1901 to 1911 three of the series were in a three-year rotation system of corn, oats, and clover, while the remaining two series rotated in corn and oats. In 1911 these two systems were combined into a five-series field, with a crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field. The alfalfa occupies one series during a rotation of the other four crops, shifting to another series in the fifth year, thus completing the cycle of all series in twenty-five years.

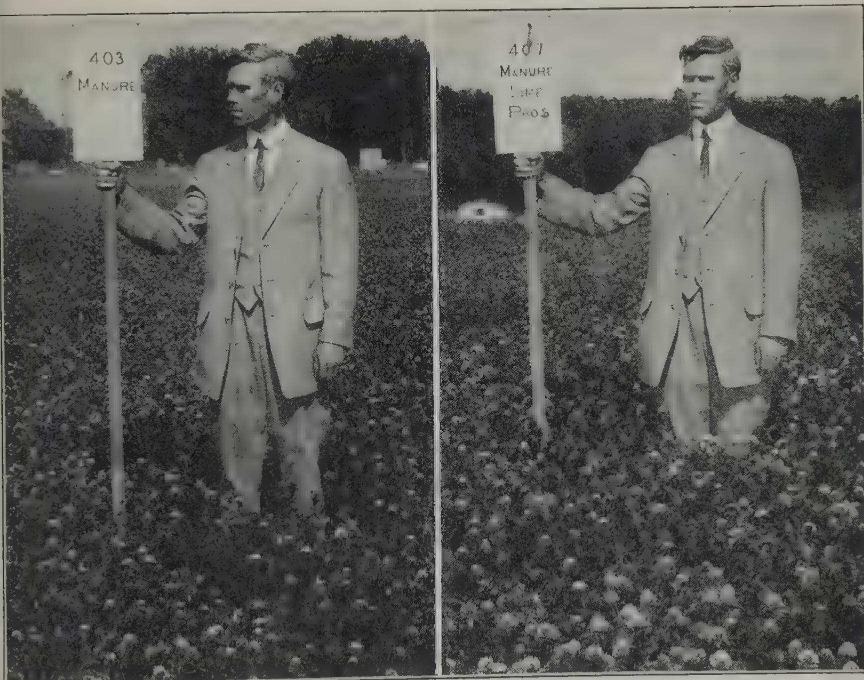
The soil treatment applied to these plots has been as follows:

Legume cover crops were seeded in the corn at the last cultivation on Plots 2, 4, 6, and 8, from 1902 to 1907, but the growth was small and the effect, if any, was to decrease the returns from the regular crops. Crop residues (**R**) have been returned to these same plots since 1907. These consist of stalks and straw, and all legumes except alfalfa hay and the seed of clover and soybeans. Beginning in 1918 a modification of the practice was made in that one cutting of the red clover crop is harvested as hay. In conjunction with these residues a catch crop of sweet clover grown with the wheat is plowed under.

Manure (**M**) was applied preceding corn, at the rate of 2 tons per acre per year in 1905, 1906, and 1907; subsequently as many tons have been applied as there have been tons of air-dry produce harvested from the respective plots.

Lime (**L**) was applied on Plots 4 to 10 at the rate per acre of 250 pounds of air-slaked lime in 1902, and 600 pounds of limestone in 1903. No further application was made until 1911, when the system of cropping was changed. Since that time applications of limestone have been made at the rate of one-half ton per acre per year.

Phosphorus (**P**) was applied on Plots 6 to 9 at the rate of 25 pounds per acre per annum in 200 pounds of steamed bone meal; but beginning with 1908 rock phosphate at the rate of 600 pounds per acre per annum was substituted for the bone meal on one-half of each of these plots. These applications continued until 1918 when adjustments were begun, first to make the rate of application of rock phosphate four times that of the bone meal, and finally to reduce the amounts of these materials to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per annum. The usual practice has been to apply and plow under at one time all phosphorus and potassium required for the rotation.



Manure
Yield: 1.43 tons per acre

Manure, limestone, phosphorus
Yield: 2.90 tons per acre

FIG. 1.—CLOVER ON THE DAVENPORT PLOTS IN 1913

Potassium (**K**) has been applied on Plots 8 and 9 in connection with the bone meal and rock phosphate, at the yearly rate of 42 pounds per acre, and mainly as potassium sulfate.

On Plot 10 about five times as much manure and phosphorus are applied as on the other plots, but this "extra heavy" treatment was not begun until 1906, only the usual amounts of lime, phosphorus, and potassium having been applied in previous years. The purpose in making these heavy applications is to try to determine the climatic possibilities in crop yields by removing the limitations of inadequate amounts of the elements of plant food.

It will be observed that the applications described above provide for the two rather distinct systems of farming already described. *The grain system,* in which animal manure is not produced and where the organic matter is provided by the direct return to the soil of crop residues along with legumes, is exemplified in Plots 2, 4, 6, and 8; and the *live-stock system,* in which farm manure is utilized for soil enrichment, is represented in the corresponding Plots 3, 5, 7, and 9.

Table 3 shows a summary of the results obtained on the Davenport plots beginning with the year 1911, when the present cropping system was introduced.

When used in conjunction with phosphorus the crop residues and the manure appear about equally effective; but where phosphorus is not applied,

TABLE 3.—URBANA FIELD, DAVENPORT PLOTS: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION
Average Annual Yields—Bushels or (tons) per acre
1911–1923

Serial plot No.	Soil treatment applied	Corn 13 crops	Oats 13 crops	Wheat 13 crops	Clover or Soybeans: Clover[1] 8 crops	Clover or Soybeans: Soybeans[2] 5 crops	Alfalfa 13 crops
1	0	54.3	52.3	25.8	(2.10)	(1.47)	2.44
2	R	55.1	53.6	28.5	1.38	19.8	2.55
3	M	65.5	64.4	28.9	(2.29)	(1.62)	2.50
4	RL	63.8	56.4	31.6	1.58	20.3	2.76
5	ML	69.3	64.8	34.2	(2.69)	(1.67)	2.99
6	RLP	70.6	69.7	42.0	1.72	23.5	3.78
7	MLP	71.6	69.2	40.9	(3.31)	(1.97)	3.87
8	RLPK	70.8	72.0	39.7	1.35	25.5	3.97
9	MLPK	69.6	71.5	40.0	(3.32)	(2.20)	3.89
10	Mx5LPx5	65.3	71.0	40.0	(2.85)	(2.22)	3.94

[1] In addition to the clover seed a crop of hay was taken from Plots 2, 4, 6, and 8 in the year 1918 and again in 1921, producing yields which reduced to an eight-year average amount to .40, .45, .50, and .50 tons respectively.
[2] Soybeans substituted when clover failed.

manure has been decidedly more effective than residues, under the conditions of the experiment. It should be observed, however, in this connection, that the plowing under of clover is a very essential feature of the residues system, and that, as a matter of fact during the thirteen years there were five clover failures, when soybeans were substituted. Perhaps with a more reliable biennial legume than red clover, the results would have been more favorable for this system.

By comparing Plots 2 and 3 with Plots 4 and 5, it is found that limestone has had a beneficial effect on practically all crops. What the financial profit amounts to depends obviously upon the market value of the crops and the cost of the limestone.

Comparing Plots 4 and 5 with Plots 6 and 7, respectively, there is found in all cases an increase in crop yield as a result of adding phosphorus. The effect on wheat is especially pronounced. Where limestone and phosphorus are applied in addition to the crop residues, an increase of 16 bushels of wheat, over the yield of the untreated land, has been obtained as a thirteen-year average.

The effect of adding potassium to the treatment is of much interest. Plots 8 and 9 are similar to Plots 6 and 7, respectively, except that potassium has been applied to the former. The small gains appearing in certain cases are counterbalanced by losses in others so that on the whole potassium treatment has not been effective on these plots.

No benefit appears as the result of the extra-heavy applications of manure and phosphorus on Plot 10. In fact the corn yields are noticeably less here than on the plots receiving the normal applications of these materials.

The University South Farm

On the University South Farm, at Urbana, several series of plots devoted primarily to variety testing and other crop-production experiments are so laid out as to show the effects of certain soil treatments that have been applied. Several different systems of crop rotation are employed and the crops are so handled as to exemplify the two general systems of farming, grain and live-stock.

TABLE 4.—URBANA FIELD, SOUTH FARM: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields 1908–1919—Bushels or (tons) per acre

Southwest Rotation: Series 100, 200, 400[1]: Wheat, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn[3] *9 crops*	Oats[3] *9 crops*	Wheat[3] *8 crops*	Clover[4] *3 crops*	Soybeans *7 crops*
RP	62.3	51.9	41.0	1.05	17.3[5]
R	51.9	46.5	26.9	1.38	16.2[5]
M	59.7	50.2	29.1	(2.28)	(1.25)
MP	64.3	55.4	43.1	(2.86)	(1.51)
RLP	60.5	57.2	41.8	.64	16.4[5]
R	49.7	49.6	25.8	.83	14.7[5]
M	55.5	54.1	27.8	(2.31)	(1.28)
MLP	64.1	59.6	43.9	(2.82)	(1.58)

North-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 1st year *9 crops*	Corn 2d year *9 crops*	Oats *9 crops*	Clover *5 crops*	Soybeans *4 crops*
RP	56.7	51.1	56.1	.54	16.9
R	51.7	45.2	52.0	.50	16.0
M	54.9	46.7	52.1	(2.29)	(1.60)
MP	56.5	53.4	56.9	(2.73)	(1.74)

South-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Corn, Soybeans

Soil treatment applied[6]	Corn 1st year *9 crops*	Corn 2d year *9 crops*	Corn 3d year *9 crops*		Soybeans *9 crops*
RP	51.9	44.0	41.3		20.0
R	45.5	39.9	35.2		19.2
M	50.1	42.1	33.5		(1.59)
MP	54.5	46.7	42.0		(1.66)

[1] Results from Series 300 and 800 are omitted on account of variation in soil type.
[2] Soybeans when clover fails.
[3] Only seven crops with limestone.
[4] Only one crop with limestone.
[5] Average of five crops.
[6] All phosphorus plots received ½ ton per acre of limestone in 1903.

The summarized results presented in Table 4 represent three different systems of cropping. The first, designated as the Southwest rotation, is to be regarded as a good rotation for general practice, on this type of soil, under Illinois conditions. This is a four-field rotation of wheat, corn, oats, and clover. The second, or North-Central rotation, consisting of corn, corn, oats, and clover, represents a system very commonly practiced; and the third or South-Central rotation, consisting of corn, corn, corn, and soybeans, must be considered as a poor rotation from the standpoint of maintaining the productiveness of the land.

On the whole, the residues have not returned as high yields as those produced by the manure treatment; but, as remarked above in the discussion of the Davenport plots, the residues system has probably been at a disadvantage thru frequent clover failures. On the North-Central rotation, where conditions seem to have been more favorable for clover, there is relatively little difference between the effect of manure and of residues.

Limestone, which has been used in the southwest rotation, appears to have produced no increase of consequence to any of the crops except oats. The com-

Residues plowed under
Yield: 35.2 bushels per acre

Residues and rock phosphate
Yield: 50.1 bushels per acre

FIG. 2.—WHEAT ON THE UNIVERSITY SOUTH FARM IN 1911

parison may be somewhat impaired, however, by a possible residual effect of the small application of limestone made in 1903 to all the phosphorus plots.

The results obtained from the use of phosphorus are of especial interest because this element has been applied on this field solely in the form of raw rock phosphate. The figures in almost every case show an increase in yield where the phosphate has been applied, and in most cases this increase is very pronounced. The wheat is especially responsive to phosphorus.

The records from this field furnish some interesting comparisons of corn yields produced under different systems of cropping. Table 5 gives a general

TABLE 5.—COMPARING PRODUCTION OF CORN IN THREE DIFFERENT ROTATION SYSTEMS
ACRE YIELDS FROM PLOTS ON THE UNIVERSITY SOUTH FARM
Twelve-Year Average (1908–1919)—Bushels per acre

Rotation	Wheat-corn-oats-legume[1]	Corn-corn-oats-legume[2]		Corn-corn-corn-legume[3]		
Treatment	Corn	1st Corn	2d Corn	1st Corn	2d Corn	3d Corn
Organic manures	55.8	53.3	46.0	47.8	41.0	34.3
Organic manures, phosphorus	63.2	56.6	52.3	53.2	45.3	41.6

[1] Clover 3 crops, and soybeans 7 crops.
[2] Clover 5 crops, and soybeans 5 crops.
[3] Soybeans 9 crops.

summary of the corn yields only, in which the results from the residues and manure treatments are averaged together as "organic manures." The highest annual acre-yields are found where corn occurs but once in a rotation. Where corn is grown twice in succession, the annual acre-yields are less; and where corn occurs three times, there is a further reduction. Also, the first crop of corn within a rotation produces more than the second, and the second crop yields more than the third. These are useful facts for consideration in connection with problems of general farm management.

The Bloomington Field

The experiments on the Bloomington field are of interest in connection with the management of Brown Silt Loam. This field is located in McLean county, northeast of the city of Bloomington. The work was started in 1902. Altho a fairly long period of years has been covered in these experiments, the field has only a single series of plots, so that only one kind of crop is represented each season. The crops employed have been corn, corn, oats, clover, and wheat; and, since 1905, they have been grown in the sequence named.

On account of irregularities in the land, results from Plots 1 and 10 are not considered altogether reliable. Therefore, they are not included in the figures presented. Since these are the only unlimed plots, no conclusions can be drawn regarding the action of limestone on this field.

Commercial nitrogen applied in the form of dried blood was used in the early years up to 1905, when crop residues and clover were substituted. The phosphorus on this field has always been applied in the form of steamed bone meal and at the rate of 200 pounds per acre per year.

Table 6 presents a summary of the work by annual average yields for the corn, oats, and wheat crops. The comparisons in the lower part of the table show the effect of the different plant-food materials in the various combinations in which they have been applied.

As might be expected the residues treatment, supplying organic matter and nitrogen, shows a beneficial effect. It is of interest to note that the effect of the residues is greater on the phosphorus plots than on those not receiving phosphorus.

The outstanding feature of the results on the Bloomington field is the effect of phosphorus as it occurs in steamed bone meal. In every crop on every plot where bone meal has been applied there is a remarkable response to the treatment as shown by the increases in yields. This response appears in all the combinations, even without the presence of residues, altho in combination with either residues or potassium the effect is accentuated. For example, comparing Plot 3 with Plot 6 (limestone and residues with limestone, residues, and phosphorus) we find the phosphorus treatment has produced an average increase in the yield of corn of about 13 bushels per acre while the yield of oats has been increased by about 20 bushels, and that of wheat by about 22 bushels, per acre. Similar increases, tho not so pronounced, appear in comparing Plot 5 with Plot 8 where potassium instead of residues is present.

Thus it appears that on this field, under this system of farming, the lack of phosphorus is distinctly a limiting factor in production and the application

TABLE 6.—BLOOMINGTON FIELD: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields of Grain Crops, 1902–1903—Bushels per acre.

Serial plot No.	Soil treatment applied	Corn *10 crops*	Oats *4 crops*	Wheat *4 crops*
2	L	41.5	44.7	24.1
3	LR	47.5	46.2	27.9
4	LP	55.8	54.3	45.7
5	LK	46.2	43.5	25.5
6	LRP	60.6	66.0	49.7
7	LRK	48.6	46.8	27.5
8	LPK	60.9	57.2	44.5
9	LRPK	64.2	63.1	50.4
	Increases: Bushels per acre			
For Residues				
	LR over L	6.0	1.5	3.8
	LRP " LP	4.8	11.7	4.0
	LRK " LK	2.4	3.3	2.0
	LRPK " LPK	3.3	5.9	5.9
For Phosphorus				
	LP over L	14.3	9.6	21.6
	LRP " LR	13.1	19.8	21.8
	LPK " LK	14.7	13.7	19.0
	LRPK " LRK	15.6	16.3	22.9
For Potassium				
	LK over L	4.7	−1.2	1.4
	LRK " LR	1.1	.6	−.4
	LPK " LP	5.1	2.9	−1.2
	LRPK " LRP	3.6	−2.9	.7

of this element in the form of steamed bone meal is attended by a high financia profit. It is of extreme interest to know whether a similar response would fol low the use of other phosphorus carriers, such as rock phosphate and acid phos phate, and experiments are now under way designed to answer this question.

Quite different are the results from the use of potassium on this field. The potassium has been applied mainly in the form of potassium sulfate, but in 1917 when this material became unavailable thru war conditions, potassium carbonate was substituted. There is a moderate increase in the corn yield where potassium has been used and particularly where residues are absent. Otherwise, the small gains shown on some plots are offset by losses on other plots, but these small differences are probably well within the limits of experimental error.

DUNE SAND

The Oquawka experiment field, located on Dune Sand, should be of especial interest in this Report, inasmuch as it represents a soil type that occupies more than one fifth of the area of Mason county.

In 1913 the University came into possession of a tract of Dune Sand, Terrace, in Henderson county, near the Mississippi river, upon which an experiment field was laid out to determine the needs of these sand soils. This field is divided into six series of plots. Corn, soybeans, wheat, sweet clover, and rye, with a catch crop of sweet clover seeded in the rye on the residues plots, are

TABLE 7.—OQUAWKA FIELD: DUNE SAND, TERRACE
Average Annual Yields 1915–1923—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn	Soybeans 8 crops		Wheat	Sweet clover[1] 7 crops		Rye	Alfalfa
		9 crops	Hay *5 crops*	Seed *3 crops*	*9 crops*	Hay *4 crops*	Seed *3 crops*	*7 crops*	*6 crops*
1	0..........	17.8	(.89)	8.1	7.3	(.00)	.00	11.7	(.32)
2	M..........	22.1	(1.01)	9.7	10.0	(.00)	.00	12.8	(.52)
3	ML..........	27.8	(1.27)	12.8	13.4	(1.20)	1.06	22.7	(1.98)
4	MLP..........	26.2	(1.20)	13.0	13.7	(1.26)	.99	21.6	(2.12)
				Seed *8 crops*		Hay *2 crops*	Seed *5 crops*		
5	0..........	17.4		5.6	9.5	(.00)	.00	11.8	(.07)
6	R..........	20.4		5.7	10.3	(.00)	.00	12.9	(.06)
7	RL..........	34.6		8.8	13.0	(1.47)	1.61	23.9	(1.79)
8	RLP..........	34.0		8.9	13.6	(1.39)	1.45	24.5	(1.71)
9	RLPK..........	37.5		8.3	12.4	(1.53)	1.72	25.3	(1.86)
10	0..........	17.0	(.60)	6.1	7.9	(.00)	.00	11.0	(.03)

[1] In 1918 sweet clover was killed by being cut for hay. Soybeans were seeded on these plots and the following yields obtained: .86, 1.10, 1.93, and 2.00 tons of hay per acre on Plots 1 to 4; 11.1, 9.9, 14.6, 15.8, and 16.6 bushels of seed per acre on Plots 5 to 9; and .62 ton of hay per acre on Plot 10.

grown in rotation on five series, while the sixth series is devoted to alfalfa. When sweet clover seeded in the wheat fails, cowpeas are substituted.

No catch of alfalfa or of sweet clover was obtained till the alfalfa drill was used in seeding. With this implement the seed is covered about one-half inch deep.

Table 7 indicates the kinds of treatment applied, the amounts of the materials used being in accord with the standard practice, as explained on page 49.

The data make apparent the remarkably beneficial action of limestone on this sand soil. Where limestone has been used in conjunction with crop residues, the yield of corn has been doubled. The limestone has also produced good crops of rye and fair crops of sweet clover and alfalfa.

This land appears to be quite indifferent to treatment with rock phosphate. The analyses show, however, that the stock of phosphorus in this type of soil is not large, and it may develop as time goes on and the supply diminishes along with the production of good-sized crops, that the application of this element will become profitable. It is also quite possible that a more available form of phosphate could be used to advantage on this very sandy soil.

Altho the results show an increase of 3.5 bushels of corn from the use of potassium salts, with ordinary prices this would not be a profitable treatment. The slight increase on the potassium plot appearing in some of the other crops can scarcely be considered significant.

A significant fact which the general summary does not bring out is that the improvement under favorable treatment has been progressive, as evidenced by a very marked upward trend in production after the first few years. For example, we note that the yield of corn under the limestone-residues treatment has been 34.6 bushels per acre as an average for the 9 crops since full treatment started, but if we take an average of the last five crops the yield rises to 42.7 bushels. Likewise the wheat under this same treatment gives for the 9-year average 13 bushels, but the last five years has given 16.9 bushels.

Manure
Yield: Nothing

Manure and limestone
Yield: 4.43 tons per acre

Fig. 3.—Alfalfa on Oquawka Field in 1918

Experience thus far shows rye to be better adapted to this land than wheat, and both alfalfa and sweet clover thrive better than soybeans. With these two legume crops thriving so well under this simple treatment, we have promise of great possibilities for the profitable culture of this land, which hitherto has been considered as practically worthless.

DEEP PEAT

The results secured on the Manito experiment field which was located on Deep Peat and which was in operation during the years 1902 to 1905, inclusive, are presented in Table 8.

There were ten plots receiving the treatments indicated in the table. Where potassium was applied, the yield was from three to four times as large as where nothing was applied. Where approximately equal money values of kainit and potassium chlorid were applied, slightly greater yields were obtained with the potassium chlorid, which, however, supplied about one-third more potassium than the kainit. However, either material furnished more potassium than was required by the crops produced.

The use of 700 pounds of sodium chlorid (common salt) produced no appreciable increase over the best untreated plots, indicating that where potassium is itself actually deficient, salts of other elements cannot take its place.

Applications of 2 tons per acre of ground limestone produced no increase in the corn crops, either when applied alone or in combination with kainit, either the first year or the second.

Reducing the application of kainit from 600 to 300 pounds for each two-year period reduced the total yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainit (Plot 9) furnished 60 pounds of potassium for the four years, an amount sufficient for 84 bushels of corn (grain and stalks). It is interesting to note that this is practically the difference between the yield of Plot 9 (125.9 bushels) and the yield obtained from Plot 2 (42.9 bushels), the poorest untreated plot.

TABLE 8.—MANITO FIELD: DEEP PEAT
Annual Corn Yields—Bushels per acre

Plot No.	Soil treatment for 1902	Corn 1902	Corn 1903	Soil treatment for 1904	Corn 1904	Corn 1905
1	None	10.9	8.1	None	17.0	12.0
2	None	10.4	10.4	Limestone, 4000 lbs	12.0	10.1
3	Kainit, 600 lbs	30.4	32.4	Limestone, 4000 lbs.; Kainit. 1200 lbs	49.6	47.3
4	Kainit, 600 lbs.; Acidulated bone, 350 lbs	30.3	33.3	Kainit, 1200 lbs.; Steamed bone, 395 lbs	53.5	47.6
5	Potassium chlorid, 200 lbs	31.2	33.9	Potassium chlorid, 400 lbs	48.5	52.7
6	Sodium chlorid, 700 lbs	11.1	13.1	None	24.0	22.1
7	Sodium chlorid, 700 lbs	13.3	14.5	Kainit, 1200 lbs	44.5	47.3
8	Kainit, 600 lbs	36.8	37.7	Kainit, 600 lbs	44.0	46.0
9	Kainit, 300 lbs	26.4	25.1	Kainit, 300 lbs	41.5	32.9
10	None	[1]...	14.9	None	26.0	13.6

[1]No yield was taken in 1902 because of a misunderstanding.

PEATY LOAM ON SAND

In 1902 an experiment field representing Peaty Loam On Sand was established about five miles northeast of Tampico in Whiteside county. The experiments were continued only three years. The soil is described as a black, peaty material rich in organic matter to a depth of 16 inches. Between 16 and 30 inches the material is lighter in color and somewhat sandy, with little organic matter. The subsoil below 30 inches is almost pure, coarse sand.

This field comprized a single series of 10 plots and the treatment included the application of lime, nitrogen, phosphorus, and potassium in different combinations as shown in Table 9. Air-slacked lime was applied the first year at the rate of 450 pounds per acre. The nitrogen was applied in the form of dried blood at the rate of about 800 pounds per acre per year. As the source of phosphorus, steamed bone meal was used at the rate of about 200 pounds per acre per year. Potassium was applied mainly as potassium chlorid, about 200 pounds per acre being used the first year and 100 or 200 pounds each year thereafter.

Altho these experiments were conducted only three years very marked results were obtained as the figures in the table show. Lime produced no visible

TABLE 9.—TAMPICO FIELD: PEATY LOAM ON SAND
Annual Corn Yields—Bushels per acre.

Serial Plot No.	Soil treatment applied	1902 Corn	1903 Corn	1904 Corn
1	0	0.0	0.0	0.0
2	L (and K after 2 years)	0.0	0.0	26.9[1]
3	LN	0.0	0.0	0.0
4	LP	0.0	0.0	0.0
5	LK	34.1	45.4	45.2
6	LNP	0.0	0.0	0.0
7	LNK	37.6	58.7	44.1
8	LPK	35.3	46.8	43.0
9	LNPK	56.5	65.9	44.0
10	NPK	49.4	58.6	35.6[2]

[1] 125 pounds potassium sulfate per acre was applied to Plot 2 in 1904.
[2] No potassium was applied to Plot 10 in 1904.

effect, and the subsequent analysis of the soil samples taken at the time th field was located also shows that the soil was not in need of lime.

It will be observed that no corn was produced except where potassium wa applied and that from every plot on which potassium was applied, a fair cro of corn was harvested, the yield varying from 41 to 55 bushels per acre as 3-year average. According to the records, poor drainage and an excessive rain fall during the experiment probably caused some irregularities in the result from some of the plots and doubtless these same conditions curtailed the yield to some extent.

The largest yield was obtained where full treatment was in effect, but o account of the meagerness of the data a very close further analysis of the result is scarcely warranted.

Lime and Potassium Lime, Nitrogen, and Phosphorus

FIG. 4.—CORN ON THE TAMPICO FIELD

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 29

MERCER COUNTY SOILS

By R. S. SMITH, E. E. DeTURK, F. C. BAUER, and L. H. SMITH

URBANA, ILLINOIS, JUNE, 1925

The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or landowner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and landowner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due the late Professor J. G. Mosier, under whose direction the soil survey of Mercer county was conducted, and to Mr. S. V. Holt, who was in direct charge of the field party in the construction of the map.

CONTENTS OF SOIL RFPORT No. 29

MERCER COUNTY SOILS

APPENDIX

SUPPLEMENT

MERCER COUNTY SOILS

By R. S. SMITH, E. E. DE TURK, F. C. BAUER, AND L. H. SMITH[1]

LOCATION AND CLIMATE OF MERCER COUNTY

Mercer county is located in the northwestern part of Illinois, bordering the Mississippi river. It is a medium-sized county, about 548 square miles in area, 150 square miles of which is in the Mississippi river terrace and bottom. It lies in the region which was covered by the Illinoisan ice sheet during the Glacial period. Nearly all the land of the county is tillable, altho about 125 square miles, or 23 percent of the total area, is subject to active erosion and must be farmed with care if serious damage from washing is to be avoided. Some areas are so broken that they should be left in permanent pasture, or returned to timber.

The climate of Mercer county has a fairly wide range of temperature between the extremes of winter and summer. The greatest range for any one year in the twenty-year period from 1902 to 1922 was 125 degrees in 1905, 1916, and 1918. The lowest temperature recorded during this period was $-30°$, the highest 104°. The average date of the last killing frost in spring is April 28; the earliest in fall, October 15. The length of the growing season is, therefore, about 169 days.

The average annual rainfall for the county during the period from 1902 to 1922 was 33.09 inches. The average rainfall by months for this period was as follows: January, 1.59 inches; February, 1.27; March, 2.13; April, 3.15; May, 4.50; June, 3.94; July, 3.54; August, 3.11; September, 4.50; October, 2.32; November, 1.93; December, 1.31.

AGRICULTURAL PRODUCTION

Mercer county is agricultural in its interests. It is particularly well suited to livestock farming because the nature of the topography is such that certain portions of many of the farms in the county are especially adapted to pasturing, while other portions are adapted to growing the general farm crops. This combination of pasture and cropping land favors livestock farming.

According to the Fourteenth Census of the United States, there were in 1919 in this county, 2,022 farms having an average of 160.6 acres each, 129.7 acres of which were improved. Ninety-four percent of the county was in farms. During the past ten years there had been a slight decrease in tenantry

The principal crops grown are corn, oats, wheat, barley, rye, and forage crops. The Census reports the following acreage and yields of the most important crops for 1919. It should be borne in mind that these figures represent the yields of only a single season.

---

[1] R. S. Smith, in charge of soil survey mapping; E. E. DeTurk, in charge of soil analysis; F. C. Bauer, in charge of experiment fields; L. H. Smith, in charge of publications.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn	94,080	4,099,112 bu.	43.6 bu.
Oats	34,082	1,035,235 bu.	30.4 bu.
Wheat	12,364	273,868 bu.	22.1 bu.
Barley	1,986	39,358 bu.	19.8 bu.
Rye	3,827	39,795 bu.	10.4 bu.
Timothy	8,227	10,454 tons	1.27 tons
Timothy and clover mixed	15,910	22,263 tons	1.40 tons
Clover	8,555	10,722 tons	1.25 tons
Alfalfa	535	1,442 tons	2.70 tons
Silage crops	2,068	17,324 tons	8.37 tons
Corn for forage	1,566	3,399 tons	2.17 tons

The appearance of the farms indicates that agriculture is relatively pro
perous in Mercer county. Livestock farming should be further developed i
order profitably to increase the acreage in permanent pasture and thus insu
better control over erosion on the steeper slopes. The acreage of sweet clov
for pasture and alfalfa for hay should be increased. Much of the rougher lar
of the county might be used for these purposes to good advantage.

The following table shows the distribution of livestock and livesto
products, together with dairy products.

Animals and Animal Products	*Number*	*Value*
Horses	14,739	$1,433,405
Mules	1,459	191,089
Beef cattle	30,501	2,090,127
Dairy cattle	7,980	536,316
Sheep	15,502	177,734
Swine	119,337	2,822,075
Poultry	212,588	210,339
Eggs and chickens	———	495,646
Dairy products	———	302,872
Wool	94,850 lbs.	49,802

Fruit and vegetable growing has been of small importance. Nearly eve
farm has a small truck garden and orchard. More fruit is grown in the regi
north of Mannon than in any other portion of the county. The character
the soil and the rough topography of the region makes it well adapted for fru
growing. In the sand terrace, near Keithsburg and New Boston, the melon i
dustry has grown rapidly because of the character of the soil.

GEOLOGY OF SOILS

An important period in the geological history of Illinois from the stan
point of soil formation was the Glacial period, during and following whi
time the materials were deposited from which the soils of the state have
large part been formed.

At that time snow and ice accumulated in the region of Labrador and
the west of Hudson Bay in such large amounts that the mass pushed outwa
from these centers, chiefly southward. In moving across the country from t
north, the ice gathered up all sorts and sizes of material including clay, si
sand, gravel, boulders, and even large masses of rock. As the ice mass push
along over its bed an immense amount of rock powder was produced by t
grinding or file-like action of the rock material imbedded in the ice. The fro
of the ice continued to advance until the rate of melting back just balanc
the rate of forward movement. During the time when the front of the ice w

LEGEND

500 Upper Illinois Glaciation

800 Deep Loess Areas

(a) UPLAND PRAIRIE SOILS

- 26 / 526 — Brown silt loam
- 71 / 871 — Brown fine sandy loam
- 20 / 520 — Black clay loam

(b) UPLAND TIMBER SOILS

- 34 / 534 — Yellow-gray silt loam
- 35 / 535 — Yellow silt loam
- 74 / 874 — Yellow-gray fine sandy loam
- 75 / 875 — Yellow fine sandy loam

(c) 1500 TERRACE SOILS

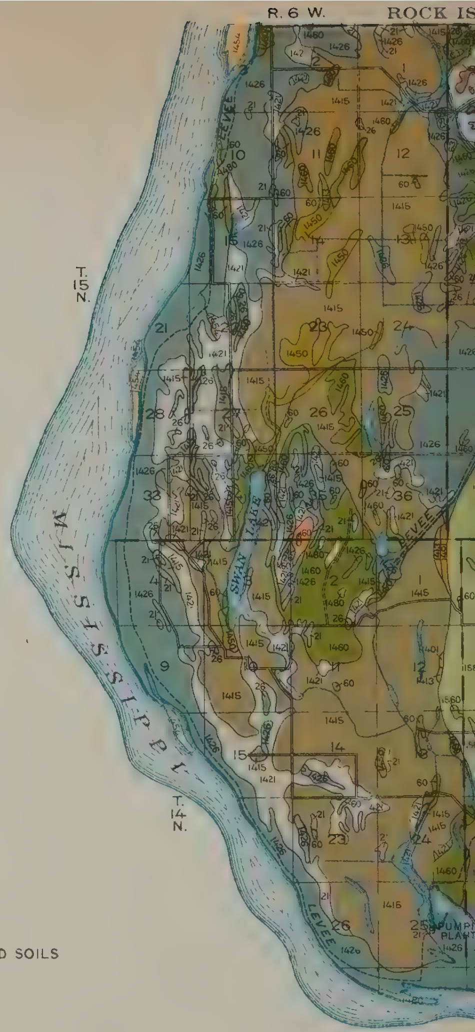
- 26 / 1526 — Brown silt loam
- 71 / 1571 — Brown fine sandy loam
- 60 / 1560 — Brown sandy loam
- 81 / 1581 — Dune sand
- 28 / 1528 — Brown-gray silt loam on tight clay
- 1534 — Yellow-gray silt loam
- 64 / 1564 — Yellow-gray sandy loam
- 1520 — Black clay loam

(d) 1300 OLD SWAMP AND BOTTOM LAND SOILS

- 1326 — Deep brown silt loam
- 1354 — Mixed loam
- 1320 — Black clay loam

(e) 1400 LATE SWAMP AND BOTTOM LAND SOILS

- 1415 — Drab clay
- 26 / 1426 — Deep brown silt loam
- 1454 — Mixed loam
- 21 / 1421 — Drab clay loam
- 60 / 1460 — Brown sandy loam
- 1450 — Black mixed loam
- 63 / 1463 — Mixed sandy loam
- 1401 — Deep peat
- 1413 — Muck on clay
- 80 / 1480 — River sand



Scale
0 1/4 1/2 1 2 Miles

SOIL
UNIVERSITY OF

Y MAP OF MERCER COUNTY

stationary, the rock material which was brought forward accumulated in a broad, usually undulating ridge, known as a terminal moraine. When the ice front receded, owing to the melting back being more rapid than the forward movement, the material carried in the ice was deposited more or less regularly over the area previously covered. A deposit formed thru such a process is known as a ground moraine.

During the Glacial period at least six distinct ice advances occurred that were separated by long periods of time. They are described as follows, in the order of their occurrence:

(1) The Nebraskan, which did not touch Illinois; (2) the Kansan, which covered the western parts of Hancock and Adams counties; (3) the Illinoisan, which covered all of the state except the northwest county (Jo Daviess), the southern part of Calhoun county, and the seven southernmost counties; (4) the Iowan, which covered a part of northern Illinois, the exact area, however, being difficult to determine because of the effect of the subsequent glaciations; (5) the early Wisconsin, which covered the northeastern part of the state as far west as Peoria and as far south as Shelbyville; (6) the late Wisconsin, which extended to the west line of McHenry county and south of the town of Milford in Iroquois county.

Only one of these great ice sheets, the Illinoisan, covered the area that now constitutes Mercer county. Previous to the ice invasion, this region was rough and hilly. The ice sheet cut down the higher points and filled the preglacial valleys with drift. The depth of the drift now varies from about 50 feet in the southern and western parts of the county to about 150 feet in the northern and eastern parts. Following this period the entire upland was covered by a wind-blown deposit, known as loess, which constitutes the mineral portion of the present soil excepting on slopes where erosion has exposed the till. In the western part of the county bordering the Mississippi bottom, the loess reaches a depth of 40 feet.

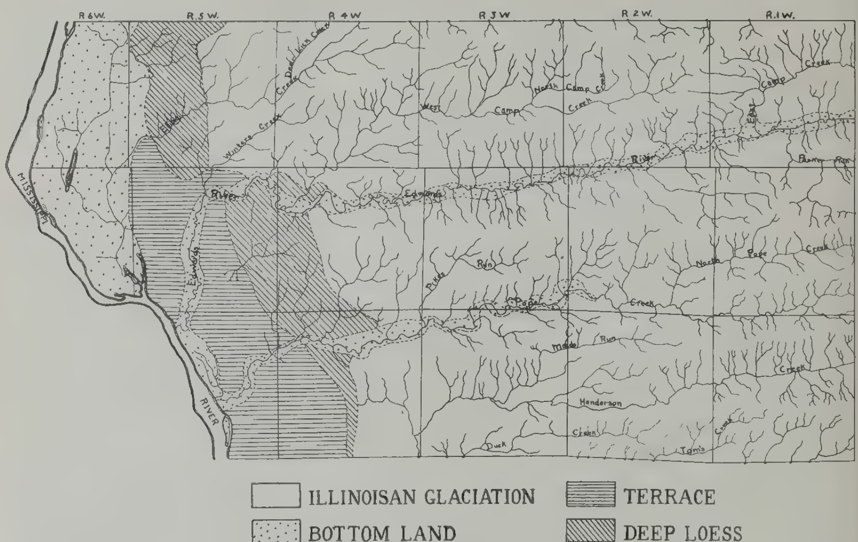
PHYSIOGRAPHY AND DRAINAGE

Mercer county presents striking variations in topography. The prairie areas vary from flat in the northern part of the county, between the towns of Hamlet and Preemption, to strongly undulating or rolling in the southern part of the county south of Pope creek. The topographic features of the county owe their origin to glacial action and to water and wind action. The undulating to rough nature of the topography adjacent to the Mississippi bottom is due in large part to the action of wind in drifting the sandy and fine sandy soil material.

The drainage of the county is thru two nearly parallel streams, Edwards river and Pope creek, which traverse the county in an east-west direction (see accompanying drainage map). The drainage of the county is good. The Mississippi bottoms were formerly swampy but since the construction of levees and dredge ditches, and the installation of pumping stations, practically the entire area is under cultivation.

The altitude of Mercer county varies from 535 feet in the Mississippi bottom at Keithsburg to about 812 feet in the eastern part of the county. The

altitudes of a few points in Mercer county are as follows: Aledo, 735 feet; Alexis, 690; Joy, 697; Keithsburg, 535; New Boston, 539; New Windsor, 806.



MAP SHOWING THE DRAINAGE BASINS OF MERCER COUNTY WITH UPLAND, TERRACE, BOTTOM-LAND, AND DEEP-LOESS AREAS

SOIL GROUPS

The soils of Mercer county are divided into four groups as follows:

(a) *Upland Prairie Soils,* usually rich in organic matter. These areas were originally covered with wild prairie grasses, the partially decayed roots of which have been the chief source of the organic matter.

(b) *Upland Timber Soils,* including those soils often found along stream courses, over which forests grew for a long period of time. These soils contain much less organic matter than the prairies because the large roots of dead trees and the surface accumulation of leaves, twigs, and fallen trees suffered almost complete decay or were burned by forest fires. The timbered soils are divided into two sub-groups, the undulating and the eroded.

(c) *Terrace Soils,* formed from deposits laid down by flooded streams during high water at the time of the melting of the glaciers. Finer deposits which were later made upon the coarser material now constitute the major part of the mineral portion of the soil. Large quantities of sand deposited on certain portions of the terrace have been reworked by the wind. These areas constitute the sand dune region of Mercer county.

(d) *Swamp and Bottom Lands,* which include flood plains along streams and some poorly drained muck and peat areas.

Table 1 gives a list of the soil types found in Mercer county, the area of each type in square miles and in acres, and also its percentage of the total area.

LEGEND

500 Upper Illinois Glaciation

800 Deep Loess Areas

(a) UPLAND PRAIRIE SOILS

26 526	Brown silt loam
71 871	Brown fine sandy loam
20 520	Black clay loam

(b) UPLAND TIMBER SOILS

34 534	Yellow-gray silt loam
35 535	Yellow silt loam
74 874	Yellow-gray fine sandy loam
75 875	Yellow fine sandy loam

(c) 1500 TERRACE SOILS

26 1526	Brown silt loam
71 1571	Brown fine sandy loam
60 1560	Brown sandy loam
81 1581	Dune sand
28 1528	Brown-gray silt loam on tight clay
1534	Yellow-gray silt loam
64 1564	Yellow-gray sandy loam
1520	Black clay loam

(d) 1300 OLD SWAMP AND BOTTOM LAND SOILS

1326	Deep brown silt loam
1354	Mixed loam
1320	Black clay loam

(e) 1400 LATE SWAMP AND BOTTOM LAND SOILS

1415	Drab clay
26 1426	Deep brown silt loam
1454	Mixed loam
21 1421	Drab clay loam
60 1460	Brown sandy loam
1450	Black mixed loam
63 1463	Mixed sandy loam
1401	Deep peat
1413	Muck on clay
80 1480	River sand

Scale
0 ¼ ½ 1 2 Miles

VEY MAP OF MERCER COUNTY

The accompanying map shows the location and boundary of each type of soil down to areas of only a few acres in extent.

For explanations concerning the classification of soils and interpretation of the map and tables, the reader is referred to the first part of the Appendix to this report.

TABLE 1.—SOIL TYPES OF MERCER COUNTY

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (500, 800)			
526	Brown Silt Loam	210.22	134 541	38.36
871	Brown Fine Sandy Loam	5.39	3 449	.98
520	Black Clay Loam	.40	256	.08
		216.01	138 246	39.42
	(b) Upland Timber Soils (500, 800)			
535	Yellow Silt Loam	109.99	70 394	20.07
534	Yellow-Gray Silt Loam	45.07	28 845	8.22
875	Yellow Fine Sandy Loam	16.18	10 355	2.95
874	Yellow-Gray Fine Sandy Loam	13.33	8 531	2.43
		184.57	118 125	33.67
	(c) Terrace Soils (1500)			
1526	Brown Silt Loam	16.63	10 643	3.04
1581	Dune Sand	13.19	8 442	2.41
1560	Brown Sandy Loam	9.43	6 035	1.72
1571	Brown Fine Sandy Loam	7.96	5 094	1.45
1528	Brown-Gray Silt Loam On Tight Clay	3.16	2 022	.58
1534	Yellow-Gray Silt Loam	3.01	1 926	.55
1564	Yellow-Gray Sandy Loam	2.32	1 485	.42
1520	Black Clay Loam	.32	205	.06
		56.02	35 853	10.23
	(d) Swamp and Bottom-Land Soils (1400)[1]			
1326, 1426	Deep Brown Silt Loam	51.61	33 030	9.42
1415	Drab Clay	17.35	11 104	3.17
1354, 1454	Mixed Loam	10.04	6 426	1.83
1421	Drab Clay Loam	5.12	3 277	.94
1460	Brown Sandy Loam	4.19	2 682	.76
1450	Black Mixed Loam	.70	448	.13
1320	Black Clay Loam	.36	230	.07
1463	Mixed Sandy Loam	.27	173	.05
1401	Deep Peat	.10	64	.02
1413	Muck On Clay	.08	51	.01
1480	River Sand	.08	51	.01
		89.90	57 536	16.41
	Water	1.49	954	.27
	Total	547.99	350 713	100.00

[1]See note on page 20 concerning subdivision of this group.

INVOICE OF THE ELEMENTS OF PLANT FOOD IN MERCER COUNTY SOILS

In order to obtain a knowledge of its chemical composition, each soil typ is sampled in the manner described below and subjected to chemical analysi for its important plant-food elements. For this purpose samples are take usually in sets of three to represent different strata in the top 40 inches o soil; namely, an upper stratum (0 to 6⅔ inches), a middle stratu (6⅔ to 20 inches), and a lower stratum (20 to 40 inches).

This, of course, is a purely arbitrary division of the soil section, very usefu in arriving at a knowledge of the quantity and distribution of the elements o plant food in the soil, but it should be borne in mind that these strata seldo coincide with the natural strata as they actually exist in the soil and which ar referred to in describing the soil types as surface, subsurface, and subsoil. B this system of sampling we have represented separately three zones for plan feeding. The upper, or surface layer, includes at least as much soil as is ord narily turned with the plow, and this is the part with which the farm manur limestone, phosphate, or other fertilizing material is incorporated.

The chemical analysis of a soil, obtained by the methods here employe gives the invoice of the total stock of the several plant-food materials actuall present in the soil strata sampled and analyzed. It should be understood, how ever, that the rate of liberation from their insoluble forms, a matter of at leas equal importance, is governed by many factors.

For convenience in making application of the chemical analyses, the r sults as presented here have been translated from the percentage basis and ar given in the accompanying tables in terms of pounds per acre. In this, th assumption is made that for ordinary types a stratum of dry soil of the area o an acre and 6⅔ inches thick weighs 2,000,000 pounds, exceptions being mad of certain soils very high in organic matter, such as the peats and the muck It is understood, of course, that this value is only an approximation, but it believed that with this understanding, it will suffice for the purpose intende It is, of course, a simple matter to convert these figures back to the percentag basis in case one desires to consider the information in that form.

THE UPPER SAMPLING STRATUM

In Table 2 are reported the amount of organic carbon (which serves as measure of the total organic matter), and the total quantities of nitroge phosphorus, sulfur, potassium, magnesium, and calcium in 2 million pounds the surface soil of each type in Mercer county.

Because of the extreme variations frequently found within a given so type with respect to the presence of limestone and acidity in different strat no attempt is made to include in the tabulated results figures purporting represent their averages in the respective types. In examining each soil typ in the field, however, numerous qualitative tests are made which furnish ge eral information regarding the soil reaction, and in the following discussio of the individual soil types, recommendations based upon these tests are give concerning the lime requirement of the respective types. Such recommend

tions cannot be made specific in all cases because local variations exist, and because the lime requirement may change from time to time, especially under cropping and soil treatment. Therefore, it is often desirable to determine the lime requirement for a given field, and in this connection the reader is referred to the section in the Appendix dealing with the application of limestone (page 31).

In connection with Table 2, attention is called to the variation among the various soil types with respect to their content of the different plant-food elements.

It will be seen from the analyses that variations in the organic carbon content of the different soils are accompanied by a similar variation in the nitrogen content. The organic-carbon content is usually from 10 to 12 times that of the total nitrogen. This close relationship is explained by the well-established facts that all organic matter of the soil contains nitrogen, and that most of the soil nitrogen, usually 98 percent or more, is present in a state of organic combination. This close relationship is also maintained in the middle and lower sampling strata.

The organic matter, with its nitrogen, varies widely in the various soils of the county. The largest amounts are found in the swamp and bottom-land soils, especially those which are peaty. Deep Peat contains 198,850 pounds per acre of organic carbon, the largest amount found in any soil type in the county. Its corresponding nitrogen content is 15,990 pounds. The upland prairie soils are much higher in these constituents than are the timber soils, the average for the upland prairie soils being 69,890 pounds per acre of organic carbon and 4,650 pounds of nitrogen, as compared to only 28,420 and 2,460 pounds of the two elements, respectively, in the timber group. The relative deficiency of the timber soils in these important constituents serves to emphasize the necessity of giving particular attention to the return of organic materials to soils of this group when planning cropping systems.

Other elements are not so closely associated with each other as are organic matter and nitrogen. However, there is some degree of correlation between sulfur and organic carbon. This is because a considerable, tho varying, proportion of the sulfur in the soil exists in the organic form, i.e., as a constituent of the organic matter.

The potassium content is always low in peaty and muck soils, the minimum for Mercer county being 10,030 pounds per acre in Deep Peat. With the exception of peaty soils the potassium content averages about 30,000 pounds. The maximum amount, as shown in the analyses, is 36,580 pounds per acre in Drab Clay Loam, Bottom, but several other types have approximately the same amount.

The phosphorus content ranges from a minimum of 550 pounds per acre in Dune Sand, Terrace, to 2,260 pounds per acre in Black Clay Loam, Terrace.

Dune Sand contains the smallest amounts of calcium, magnesium, and phosphorus. The calcium content in this type is 6,670 pounds per acre, and that of magnesium 3,200 pounds. The maximum calcium content, 22,960 pounds, is found in Black Clay Loam, Terrace, as is also the maximum for magnesium, 14,900 pounds.

THE MIDDLE AND LOWER SAMPLING STRATA

The amounts of plant-food elements in the middle and lower sampling strata, are recorded in Tables 3 and 4.

In comparing these strata with the upper one, it will be noted that in the majority of the soil types the organic matter and nitrogen contents diminish rather rapidly with increasing depth, while the percentages of the other ele-

TABLE 2.—PLANT-FOOD ELEMENTS IN THE SOILS OF MERCER COUNTY, ILLINOIS
UPPER SAMPLING STRATUM: ABOUT 0 TO 6⅔ INCHES
Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (500, 800)							
526	Brown Silt Loam	66 560	4 830	1 140	990	32 660	7 520	11 80
871	Brown Fine Sandy Loam	43 140	3 420	1 120	720	33 080	5 440	11 46
520	Black Clay Loam	99 960	5 700	1 480	1 600	29 920	10 060	17 88
	Upland Timber Soils (500, 800)							
534	Yellow-Gray Silt Loam	32 030	2 630	840	690	35 400	6 470	8 87
535	Yellow Silt Loam	24 570	2 030	690	680	33 010	7 110	7 66
874	Yellow-Gray Fine Sandy Loam	33 360	2 960	1 040	590	33 450	4 490	12 37
875	Yellow Fine Sandy Loam	23 710	2 230	840	340	35 200	7 640	12 30
	Terrace Soils (1500)							
1526	Brown Silt Loam	47 470	3 100	1 080	900	31 350	6 380	10 43
1571	Brown Fine Sandy Loam	45 820	3 600	1 200	760	30 360	6 200	10 38
1560	Brown Sandy Loam	30 090	2 130	1 100	550	27 980	4 180	8 06
1581	Dune Sand	12 760	1 020	550	520	24 560	3 200	6 67
1528	Brown-Gray Silt Loam On Tight Clay	53 730	4 840	1 610	1 010	34 490	6 590	7 21
1534	Yellow-Gray Silt Loam	26 080	1 960	860	580	35 580	5 800	10 08
1564	Yellow-Gray Sandy Loam	18 820	1 620	720	520	27 360	4 380	8 80
1520	Black Clay Loam	195 060	17 680	2 260	2 400	26 500	14 900	22 96
	Swamp and Bottom-Land Soils (1300 and 1400)							
1326 1426	Deep Brown Silt Loam	62 120	5 120	1 795	1 080	33 120	10 290	14 39
1354 1454	Mixed Loam[1]	......	......	......	......	......	......	......
1320	Black Clay Loam	87 120	7 220	2 040	1 180	33 100	11 640	22 54
1415	Drab Clay	55 210	4 890	1 660	1 000	32 460	11 970	17 12
1421	Drab Clay Loam	58 180	4 500	2 020	960	36 580	12 500	15 90
1460	Brown Sandy Loam	46 620	4 400	1 320	880	21 920	5 580	7 90
1450	Black Mixed Loam[1]	......	......	......	......	......	......	......
1463	Mixed Sandy Loam[1]	......	......	......	......	......	......	......
1401	Deep Peat[2]	198 850	15 990	1 210	2 600	10 030	6 020	17 92
1413	Muck On Clay[3]	177 300	14 500	1 170	2 820	19 350	9 450	19 69
1480	River Sand[4]	......	......	......	......	......	......	......

LIMESTONE AND SOIL ACIDITY.—In connection with these tabulated data, it shoul be explained that the figures for limestone content and soil acidity are omitted, not because c any lack of importance of these factors, but rather because of the peculiar difficulty of pr senting in the form of general numerical averages reliable information concerning the lim stone requirement for a given soil type. A general statement, however, will be found co cerning the lime-requirement of the respective soil types in connection with the discussio which follow.

[1]On account of the heterogenous character of the mixed loams, chemical analyses are n included for these types.
[2]Amounts reported for Deep Peat are for 1 million pounds of soil.
[3]Amounts reported for Muck on Clay are for 1½ million pounds of soil.
[4]Not sampled.

ments for the most part remain about the same and in some cases increase slightly in the lower strata. In making these comparisons, it is necessary to bear in mind that the data as given for the middle and lower sampling strata are on the basis of 4 million and 6 million pounds of soil, and should therefore be divided by 2 and 3, respectively, thus converting them to a uniform basis of 2 million pounds before comparing them with each other or with the data for the upper stratum.

It is frequently of interest to know the total supply of a plant-food element accessible to the growing crops. While it is impracticable to obtain this information exactly, especially for the deeper-rooted crops, it seems probable that practically the entire feeding range of the roots of most of our common

TABLE 3.—PLANT-FOOD ELEMENTS IN THE SOILS OF MERCER COUNTY, ILLINOIS
MIDDLE SAMPLING STRATUM: ABOUT 6⅔ TO 20 INCHES
Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (500, 800)							
526	Brown Silt Loam	94 620	7 020	1 930	1 660	65 560	18 820	23 110
871	Brown Fine Sandy Loam	53 920	4 600	1 960	1 120	68 080	14 680	22 080
520	Black Clay Loam	142 080	7 920	2 520	2 320	60 920	24 560	36 800
	Upland Timber Soils (500, 800)							
534	Yellow-Gray Silt Loam	27 110	2 630	1 550	890	71 470	18 430	16 800
535	Yellow Silt Loam	22 550	1 890	1 370	960	61 950	18 840	14 600
874	Yellow-Gray Fine Sandy Loam	26 620	2 920	1 640	500	69 500	11 780	23 340
875	Yellow Fine Sandy Loam	21 680	2 280	2 060	580	69 160	21 060	26 000
	Terrace Soils (1500)							
1526	Brown Silt Loam	69 140	4 500	1 960	1 740	63 680	11 360	20 100
1571	Brown Fine Sandy Loam	64 320	5 320	1 920	1 560	63 000	12 680	20 600
1560	Brown Sandy Loam	50 100	3 900	2 060	1 320	58 440	8 700	16 500
1581	Dune Sand	17 980	1 880	1 120	840	50 060	6 340	13 200
1528	Brown-Gray Silt Loam On Tight Clay	39 840	3 500	2 420	1 400	74 840	14 960	11 920
1534	Yellow-Gray Silt Loam	23 000	1 920	1 720	1 240	72 480	18 640	18 560
1564	Yellow-Gray Sandy Loam	18 480	2 240	1 160	680	55 840	7 800	15 600
1520	Black Clay Loam	151 320	12 800	2 720	2 200	61 640	29 240	37 720
	Swamp and Bottom-Land Soils (1300, 1400)							
1326, 1426	Deep Brown Silt Loam	91 180	7 440	2 660	2 050	64 120	22 360	27 980
1354, 1454	Mixed Loam[1]	......	......	......	......	......	......	......
1320	Black Clay Loam	112 720	10 400	3 960	1 440	68 960	25 680	41 680
1415	Drab Clay	66 940	6 060	2 440	1 440	61 700	25 320	34 540
1421	Drab Clay Loam	73 720	6 160	2 800	1 040	63 360	24 360	30 960
1460	Brown Sandy Loam	35 000	3 520	2 000	960	40 840	8 760	12 640
1450	Black Mixed Loam[1]	......	......	......	......	......	......	......
1463	Mixed Sandy Loam[1]	......	......	......	......	......	......	......
1401	Deep Peat[2]	483 560	36 360	2 060	5 880	15 240	10 040	39 940
1413	Muck On Clay[3]	255 960	19 830	1 800	3 570	35 940	15 540	36 300
1480	River Sand[4]	......	......	......	......	......	......	......

LIMESTONE AND SOIL ACIDITY—See note in Table 2.

[1]On account of the heterogenous character of the mixed loams, chemical analyses are not included for these types.
[2]Amounts reported for Deep Peat are for 2 million pounds of soil.
[3]Amounts reported for Muck on Clay are for 3 million pounds of soil.
[4]Not sampled.

field crops is included in the upper 40 inches of soil. By adding together, for a given soil type, the corresponding figures in Tables 2, 3, and 4, the total amounts of the respective plant-food elements to a depth of 40 inches may be ascertained.

Wide variation in composition is found in the sub-layers as well as in the top layer of the various soil types. The tables reveal further that there is not only this wide diversity among the different soils with respect to a given plant-food element, but that there is also a great variation with respect to the relative abundance of the various elements within a given soil type, as measured by crop requirements. For example, in the most extensive soil type in Mercer

TABLE 4.—PLANT-FOOD ELEMENTS IN THE SOILS OF MERCER COUNTY, ILLINOIS
LOWER SAMPLING STRATUM: ABOUT 20 TO 40 INCHES
Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (500, 800)							
526	Brown Silt Loam	49 800	4 060	2 480	1 480	99 640	38 630	36 20
871	Brown Fine Sandy Loam	33 840	3 300	3 180	1 020	101 040	25 920	40 08
520	Black Clay Loam	67 800	3 900	3 600	1 860	85 220	42 600	48 72
	Upland Timber Soils (500, 800)							
534	Yellow-Gray Silt Loam	19 280	2 270	3 110	1 230	103 740	40 430	30 09
535	Yellow Silt Loam	19 480	1 560	1 940	1 040	89 380	29 000	22 38
874	Yellow-Gray Fine Sandy Loam	22 020	3 060	2 760	690	104 010	25 380	37 29
875	Yellow Fine Sandy Loam	24 960	2 880	3 180	810	100 260	33 840	64 20
	Terrace Soils (1500)							
1526	Brown Silt Loam	44 190	3 420	2 790	1 500	101 070	24 150	33 48
1571	Brown Fine Sandy Loam	47 040	4 200	2 460	1 380	100 140	22 620	35 40
1560	Brown Sandy Loam	36 930	3 270	3 150	1 230	86 400	15 840	25 47
1581	Dune Sand	18 810	1 950	1 500	1 110	76 920	10 920	20 58
1528	Brown-Gray Silt Loam On Tight Clay	34 020	3 930	3 630	1 350	101 580	43 410	28 62
1524	Yellow-Gray Silt Loam	24 420	1 160	3 360	1 560	105 660	37 260	30 96
1564	Yellow-Gray Sandy Loam	16 980	2 220	2 340	1 080	84 420	14 460	24 96
1520	Black Clay Loam	74 700	5 940	6 060	1 320	105 660	49 560	45 54
	Swamp and Bottom-Land Soils (1300, 1400)							
1326 1426	Deep Brown Silt Loam	67 450	5 790	2 810	2 130	96 900	31 270	37 35
1354 1454	Mixed Loam[1]	......	......	......	......	......	......	......
1320	Black Clay Loam	84 600	7 260	4 980	1 860	103 260	41 640	53 10
1415	Drab Clay	62 250	5 250	6 900	1 320	90 660	37 350	54 12
1421	Drab Clay Loam	57 480	6 060	2 400	840	92 100	32 760	44 88
1460	Brown Sandy Loam	19 440	2 640	1 920	1 140	59 700	10 860	15 30
1450	Black Mixed Loam[1]	......	......	......	......	......	......	......
1463	Mixed Sandy Loam[1]	......	......	......	......	......	......	......
1401	Deep Peat[2]	818 580	55 170	2 280	10 440	19 770	16 230	65 10
1413	Muck On Clay	230 580	16 740	1 980	3 060	85 560	31 200	63 00
1480	River Sand[3]	......	......	......	......	......	......	......

LIMESTONE AND SOIL ACIDITY—See note in Table 2.

[1]On account of the heterogenous character of the mixed loams, chemical analyses are n included for these types.
[2]Amounts reported for Deep Peat are for 3 million pounds of soil.
[3]Not sampled.

county, Brown Silt Loam, Upland, we find that the total quantity of nitrogen in an acre to a depth of 40 inches amounts to 15,910 pounds. This is about the amount of nitrogen contained in 15,900 bushels of corn. The amount of phosphorus, 5,550 pounds, contained in the same soil is equivalent to that contained in 32,600 bushels of corn; while in the same quantity of this soil, there is present 197,860 pounds of potassium, the equivalent of that contained in one million bushels of corn. In marked contrast to this soil, with respect to nitrogen is Yellow Silt Loam, the next most extensive type in the county, which contains in the 40-inch stratum approximately 5,480 pounds per acre of nitrogen, an amount equal to that in 5,480 bushels of corn. The phosphorus content is 4,000 pounds, or the equivalent of 23,500 bushels of corn, while the total amount of potassium is 184,340 pounds, equivalent to 970,000 bushels of corn. A significant variation in phosphorus content is found in Drab Clay, Bottom, which contains 11,000 pounds of this element, or the equivalent of 65,000 bushels of corn. The nitrogen and potassium in this type to a depth of 40 inches are essentially the same as in Brown Silt Loam.

These statements are not intended to imply that it is possible to predict how long it might be before a certain soil would become exhausted under a given system of cropping. Neither do the figures necessarily indicate the immediate procedure to be followed in the improvement of a soil, for other factors enter into consideration aside from merely the amount of plant-food elements present in the soil. Much depends upon the nature of the crops to be grown as to their utilization of plant-food materials, and much depends upon the condition of the plant-food substances themselves as to their availability. Finally, in planning the detailed procedure for the improvement of a soil, there enter for consideration all the economic factors involved in any fertilizer treatment. Such figures do, however, furnish an inventory of the total stocks of the plant-food elements that can possibly be drawn upon, and in this way these chemical data contribute fundamental information for the intelligent planning, in a broad way, of systems of soil management that will conserve and improve the fertility of the land.

DESCRIPTION OF INDIVIDUAL SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of Mercer county occupy 216.01 square miles, or 39.42 percent of the area of the county. They occur in irregular-shaped areas traversing the county from east to west between the areas of timber soil which occur adjacent to the streams. The dark color of the prairie soils is due to the accumulation of organic matter which is derived, very largely, from the fibrous roots of the prairie grasses. The network of grass roots was protected from rapid and complete decay by the covering of fine, moist soil material and by the mat of vegetative material formed by old grass and leaves, which was very effective in excluding oxygen from the air. On the native prairies the stems and leaves were usually burned in part by prairie fires or disappeared in part by decay. Thus they added very little organic matter to the soil, but with a constant renewal of this vegetable debris, the decay of the roots was retarded considerably.

Brown Silt Loam (526)

The Brown Silt Loam of the upland covers an area of 210.22 square miles, or 38.36 percent of the area of the county. In topography, it varies from flat to undulating, becoming somewhat rolling at the sources of small streams. Towards the south part of the county, below Edwards river, Brown Silt Loam is strongly undulating. Considerable erosion has taken place in the more undulating areas. The dark-colored surface soil has been removed by erosion to such an extent from many of the slopes that it was necessary to map them as Yellow Silt Loam, which is the type name used for eroded timber soil. The fact should also be noted that many of these areas exist which are too small to be shown on the map. In the northern part of the county, Brown Silt Loam is heavier and verges on a silty clay loam.

The surface, which is usually from 6 to 8 inches in depth, varies from a brown silt loam with a grayish cast in the area south of Edwards river to a chocolate brown silt loam in the northern part of the county. This latter area has a deeper surface soil, frequently 10 to 12 inches deep, and it is a little finer in texture. West of Aledo, in Millersburg township (Township 14 North, Range 4 West), an area of Brown Silt Loam occurs that has a gray cast in the surface. The subsurface extends to a depth of 18 or 20 inches and varies from a brown silt loam with a slightly gray cast to a light brown or a yellowish brown silt loam, with some splotches of red iron concretions.

The subsoil, which is usually found at a depth of 18 to 20 inches, is a fairly compact, drabbish gray to grayish yellow silt loam to silty clay loam in its upper portion and a drabbish yellow or grayish yellow, fairly friable silt loam, containing many dark red iron concretions, in its lower portion. The depth to glacial till varies but, excepting on eroded slopes, does not occur at less than 4 or 5 feet from the surface. No carbonates are found to a depth of 40 inches.

Management.—Brown Silt Loam is a productive soil if given reasonably good care. Much of the area occupied by this type in Mercer county is naturally well drained, but when this is not the case, as on the flat areas, the first step in economical management is to provide good underdrainage. According to the tests made, the type is either not acid or only slightly acid, excepting in the eastern row of townships and in Preemption township (Township 15 North, Range 2 West). It is of course to be expected that exceptions to this general statement occur, since the reaction of a soil is exceedingly variable. For this reason, it is suggested that before limestone is applied, or before attempting to grow such crops as alfalfa or sweet clover without applying limestone, the county farm adviser or the Agricultural Experiment Station be consulted as to the need for it and the amount needed.

If this land is to be kept in a productive condition, or restored to a productive condition after its producing power has been lowered by poor farming, it is necessary to provide for frequent additions of fresh organic matter. All farm manure should be conserved and returned to the land, preferably for corn. Deep-rooting legumes, such as sweet clover or alfalfa, should occupy a prominent place in the rotation both because of their value as crops and because of their beneficial effects on the soil.

The information available regarding the use of phosphate fertilizers on this soil type is not entirely satisfactory because of conflicting results obtained on different experiment fields. On the Aledo experiment field, in the major system of plots, rock phosphate has been used at a financial loss, whether applied with manure or with residues along with limestone. However, in the minor system of plots on this same field, rock phosphate has returned a very good profit in increased crop yields.

At Galesburg and also at Kewanee rock phosphate, where applied with stable manure, failed to return its cost, but where applied with residues it produced very pronounced crop increases at Galesburg and yielded profitable returns at Kewanee.

The reader is referred to page 43 of the Supplement to this Report, where results from the Brown Silt Loam experiment fields are presented. It is suggested that this matter of phosphorus fertilization be given earnest consideration because of the fact that Brown Silt Loam in Mercer county is not high in phosphorus, and because it is much easier to prevent the depletion of this element of plant food than to restore it after depletion has resulted in declining yields.

Brown Fine Sandy Loam (871)

Brown Fine Sandy Loam occupies 5.39 square miles, or .98 percent of the area of the county. Practically all of this type is found in the vicinity of the towns of Joy and Seaton. The area south and west of Seaton is of a more rolling topography than that near Joy.

The surface, which is about 8 inches in depth, varies from a brown to a chocolate brown, fine sandy loam. The subsurface, extending to a depth of about 18 or 20 inches, varies from a light brown to a brownish yellow, fine sandy silt loam. The subsoil varies from a slightly mottled, yellow, fine sandy silt loam in the upper part to a friable, slightly mottled, light yellow silt loam in its lower part, containing some bright red streaks which are due to the presence of iron. Carbonates occur at a depth of about 40 inches. The area of Brown Fine Sandy Loam west of Seaton does not have a distinctly developed subsurface and subsoil. The subsoil is a friable, yellowish brown, fine sandy loam. No carbonates were found to a depth of 40 inches.

Management.—Tests for reaction showed this type to vary from slight to medium acidity, indicating that about 2 tons of limestone per acre should be used if alfalfa or sweet clover is to be grown. Red clover will grow fairly successfully excepting on the most acid areas of the type. Particular attention should be given to making regular additions of fresh organic matter, preferably legume residues, catch crops, and cover crops in order to maintain and increase the nitrogen supply in the soil.

The Experiment Station has no experimental data upon which to base recommendations for the fertilization of this soil type. Its deep, friable nature favors root penetration, thus allowing the roots to come in contact with the mineral elements of plant food contained in the soil at depths which, in some soils, are not reached by roots. This consideration makes it appear doubtful

whether any fertilizing material, other than manure, can be used at a profit, but it is suggested that, after adequate nitrogen and organic matter have been provided for by the growth of clovers, preferably sweet clover, a trial be made of one or more of the phosphates for wheat. The reader is referred to page 33 of the Appendix for a discussion of the various phosphate carriers and their method of use.

Black Clay Loam (520)

Black Clay Loam, because of its small area, is of minor importance in Mercer county. It occupies only 256 acres, or .08 percent of the area of the county. It is found chiefly in the southeast part of the county, near the town of North Henderson. The individual areas are small in size and some difficulty is found in mapping them because they vary from Black Clay Loam to Brown Silty Clay Loam. All of the areas are well drained.

The surface, which is about 8 inches deep, varies from a black, silty clay loam to a black clay loam. The subsurface extending to a depth of 18 inches is a very plastic black clay loam, verging on black clay in some borings. The subsoil varies from fairly compact, drab clay loam with some streaks of yellow silt in the upper part to a somewhat friable, drabbish gray, silty clay loam in the lower part, splotched with yellow silt and reddish yellow iron concretions below 30 inches. Carbonates were not found to occur in the 40-inch section, but the type is rarely acid.

Management.—This type is rarely in need of lime and is well supplied with the elements of plant food. The important consideration in its management is the maintenance of an adequate supply of freshly decaying organic matter, in order to counteract its tendency to become hard and difficult to work. For an account of field experiments on this soil type, see page 59 of the Supplement.

(b) UPLAND TIMBER SOILS

The upland timber soils are found widely distributed thruout the county, usually bordering the streams. These soils are characterized by a relatively low organic-matter content and a light color, which varies from a yellow to a yellowish brown or yellowish gray. The lack of organic matter has been caused by the long-continued growth of forest trees. As the forests invaded the prairies, the shading of the trees prevented the growth of prairie grasses, the roots of which are mainly responsible for the large amount of organic matter in the prairie soils. The trees themselves added very little organic matter to the soils, for the leaves and other debris either decayed very completely or were burned by forest fires.

Yellow-Gray Silt Loam (534)

Yellow-Gray Silt Loam occurs as an outer, light-colored soil belt bordering the streams. The topography of this type is undulating to slightly rolling. The natural drainage is good and with reasonable care to stop small gullies, and with good farming methods, but little difficulty should be encountered with washing. The type covers 45 square miles, or 8.22 percent of the area of the county.

The surface, which is about 6 or 7 inches deep, varies from a mottled, brownish gray to yellowish gray silt loam. The subsurface extends to a depth of about 18 inches and is a strongly mottled, grayish yellow silt loam. The subsoil to a depth of about 30 inches is a fairly compact, mottled, yellow silt loam, while below this depth it is a friable, slightly mottled, yellow silt loam containing many yellowish red, iron concretions. No carbonates are found to a depth of 40 inches.

Management.—This type, as it occurs in Mercer county, shows slight to medium acidity in the surface soil and ordinarily the degree of acidity increases with increasing depth. The first step in increasing its producing power is to apply sufficient limestone to grow clover, preferably sweet clover, which should be plowed down the spring of the second year in preparation for corn.

Altho no experimental data are available on the fertilization of this soil type, it is suggested that a trial be made of the various phosphates in order to determine which one can be used at the most profit. Results on a light-colored soil with a calcareous subsoil in Lake county indicate that bone meal might be expected to cause sufficient increase in yield to pay a good return on the investment. However, the high price of bone meal suggests that basic slag, acid phosphate, or rock phosphate should be tried first.

It is urged that the problem of phosphate fertilization be given careful study because the phosphorus content of this soil is relatively low. The problem is to determine the kind of phosphate which can be used most profitably and which will at the same time return as much phosphorus to the soil as is lost thru cropping and in other ways. It is understood, of course, that all manure should be carefully conserved and returned to the land, preferably for corn unless a good growth of sweet clover is to be plowed in for corn, in which case the manure may well be used on permanent pasture or for wheat.

Yellow Silt Loam (535)

Somewhat over one-half of the timber soil area of the county is classified as Yellow Silt Loam. This type covers 110 square miles, or about 20 percent of the area of the county. It occurs as a nearly continuous belt on one or both sides of the streams, and is usually more extensively developed on the north side than on the south side. As was noted in the description of Brown Silt Loam, numerous small areas occur, thruout the more rolling portion of the prairie, from which the surface soil has been largely removed by washing. These areas, when sufficiently large, are mapped as Yellow Silt Loam because of their yellow color, even tho they are not timber soil. Many of the slopes in the timber soil areas are very steep and are gullying rapidly, with little or no attempt being made to stop this destruction. This condition is found particularly in the eastern part of the county, where the slopes are generally steeper than in the western part.

Where washing has not been active for a few years, the surface soil of this type is brownish yellow in color to a depth of 3 or 4 inches. Where washing is active, the surface is yellow. Except for the brownish yellow color of the immediate surface, as noted, the soil is very uniformly a yellow silt loam or silty clay loam down to the underlying till. On the steeper slopes, till is fre-

quently exposed. No carbonates are found until the till is penetrated 2 or 3 feet.

Management.—This type should be utilized for the most part for permanent pasture, timber, or orchards. If it is cultivated, particular attention should be given to increasing the organic-matter content and to tillage methods that will help to decrease washing. Much can be accomplished by so planning the rotation that some vegetative covering is on the land a large part of the time. It is frequently possible to control erosion at small cost by constructing broad terraces. For methods which have been used successfully in controlling erosion on this soil type, the reader is referred to the discussion of the Vienna field on page 60 of the Supplement.

Yellow-Gray Fine Sandy Loam (874)

Yellow-Gray Fine Sandy Loam occupies flat ridges between the eroded areas. It covers an area of 13.33 square miles, or 2.43 percent of the area of the county.

The surface, which is about 6 or 7 inches in depth, varies in color from a brownish gray to a grayish yellow, fine sandy loam. The subsurface, extending to a depth of 18 inches, varies from a yellowish gray, fine sandy silt loam to a yellow, fine sandy loam. The subsoil from 18 to 40 inches is a mottled, yellow, fine sandy silt loam in the upper part, and in the lower part a yellow, fine sandy silt loam to a yellow silt loam containing red iron concretions.

Management.—This type is usually slightly acid in the surface and of medium acidity in the subsoil. Carbonates occur at a depth of 5 to 6 feet, as a rule. The organic-matter and nitrogen contents of the type are low. The recommendations made for the management of Yellow-Gray Silt Loam (534) apply also to this type and the reader is referred to that discussion. Yellow-Gray Fine Sandy Loam is an excellent alfalfa soil after the acidity has been taken care of by the addition of about 3 tons of limestone per acre. It is also a good fruit soil.

Yellow Fine Sandy Loam (875)

Yellow Fine Sandy Loam occurs for the most part immediately adjacent to the bottom lands of the streams which are tributary to the Mississippi, and extends two to three miles inland from the Mississippi bluff line. It occurs in the same topographic position as Yellow Silt Loam. It covers an area of 16.18 square miles, or 2.95 percent of the area of the county. This type is badly eroded by gullying and sheet erosion, owing in part to the incoherent character of the soil strata.

The surface varies in depth from 0 to 7 inches, and in color from a yellow to brownish yellow, fine sandy loam. This variation is due in part to differences in erosion and in part to differences in organic-matter content that have resulted from different systems of management. The subsurface and subsoil consist of yellow, fine sandy loam. Till occasionally occurs in the 40-inch section because of the removal of much of the surface blanket of loess.

Management.—This type should be kept in permanent pasture or timber, or should be planted to orchard trees. It is usually not acid and frequently carbonates occur even in the surface soil; there is, however, wide variation in the depth to carbonates.

(c) TERRACE SOILS

The largest area of terrace soil in Mercer county is found south of Eliza creek, between the Mississippi river and the bluffs. North of New Boston the terrace is from 15 to 25 feet higher than the adjacent bottom land to the west. The soil material of this large terrace formation was probably deposited during, and immediately following, the Wisconsin glaciations. Small terraces also occur along the small streams which traverse the county from east to west. These formations have an elevation of 3 to 30 feet above the adjacent bottom lands.

Brown Silt Loam (1526)

Brown Silt Loam, Terrace, covers about 17 square miles, or 3 percent of the total area of the county. It is found for the most part adjacent to the bluffs south of the village of Mannon.

The surface, which is about 8 inches deep, is a brown silt loam with an appreciable percentage of fine sand near the bluff line. The subsurface extends to a depth of about 20 inches and varies in color from brownish yellow to brown and in texture from a silt loam to a fine sandy loam. Some mottling is found in this stratum. The subsoil to a depth of about 32 inches varies from a brownish yellow, sandy loam to a slightly compact, silty clay loam. Below the 32-inch depth it becomes a slightly mottled, bright yellow, silt loam. The depth to gravel is great enough so that this land is not drouthy.

Management.—This type is only slightly acid and will grow red clover successfully without the addition of lime. If alfalfa or sweet clover is to be grown, an application of 2 tons of limestone per acre should be made excepting to low areas or areas which receive some wash from the bluffs. The friable nature of this soil favors the deep growth of roots, and probably no treatment other than the use of legumes, residues, and manures is economically possible.

Brown Fine Sandy Loam (1571)

Brown Fine Sandy Loam, Terrace, occupies about 8 square miles and is found, for the most part, in the vicinity of Mannon.

The surface, which is about 8 inches deep, is a brown, fine sandy loam. The subsurface extends to a depth of about 22 inches and varies from yellowish brown, fine sand to yellow fine sand with no indication of compactness.

Management.—The management requirements of this type are not essentially different from those for the preceding type, Brown Silt Loam, Terrace, (1526). It is more difficult to maintain an adequate supply of fresh organic matter because of the more open nature of the soil. This soil is well adapted to the growth of alfalfa after the small lime requirement has been taken care of.

Brown Sandy Loam (1560)

Brown Sandy Loam, which occupies about 9.43 square miles, or 1.72 percent of the area of the county, is mapped in scattered areas in conjunction with Dune Sand. It varies in topography from flat to undulating owing to its relative position with respect to adjacent types, it being somewhat lower than Dune Sand. Near the bluffs, considerable outwash material has been deposited upon the Brown Sandy Loam.

The surface, which is about 8 or 10 inches in depth, is brown in color and a fine to medium, sandy loam in texture. The subsurface varies from a light brown, fine to medium sand. The subsoil, which begins at about 22 inches, varies from a yellowish brown sand to a yellow sand.

Management.—This type shows a slight to medium acidity. Two or three tons of limestone per acre are necessary for the growth of sweet clover or alfalfa. This soil may be used for growing any of the general farm crops and is also well adapted to trucking. One of the chief considerations in its management is the maintenance of organic matter. Decay is relatively rapid because of the open nature of the soil, and more frequent additions of organic matter must be made than with heavier soils. The subsoil is so coarse that root penetration is probably not very good, and consequently the use of one of the phosphates is advised. No experimental results are available regarding the fertilization of this type.

Dune Sand (1581)

Dune Sand occurs along the outer edge of the Mississippi river terrace south of Eliza creek. It occupies 13 square miles, or about 25 percent of the area of the terrace. The topography is typical of a dune sand region and has been produced by the wind reworking the sand and forming ridges, knobs, and hollows. The organic-matter content of this soil is very low, particularly on the higher areas. The wind is still actively moving the sand, where it is not held by vegetation, forming "blowouts" which may be very small or which may cover areas as large as 80 acres or more. This soil is very uniform thruout the 40-inch section. The immediate surface is a light brown sand or coarse sandy loam, and below this the material is a medium or coarse yellow sand.

Management.—Dune Sand shows a slight to medium acidity. It is not adapted to the production of the ordinary farm crops excepting on the low areas. Sweet clover makes an excellent growth after lime has been applied at the rate of 2 to 3 tons per acre. Following sweet clover, alfalfa does well, tho it is somewhat difficult to get a stand on such a sandy soil. Rye is the best small grain crop to grow, and after the nitrogen deficiency has been met by turning down a legume or by the application of manure, it usually makes very good yields. The use of rock phosphate is not advised because of the adverse results secured with it on the Oquawka field, which is located on the same type of soil. No information is available as to whether one of the more soluble phosphates could be used at a profit, but it is suggested that since this soil is favorable to root penetration, the use of any of the phosphates on it be limited to small areas until their value has been demonstrated.

Brown-Gray Silt Loam On Tight Clay (1528)

Brown-Gray Silt Loam On Tight Clay occurs as a terrace formation along Edwards river north and east of Aledo, and in the Mississippi river terrace east of Keithsburg. The areas along Edwards river slope gently to the bottom land while those in the Mississippi river terrace occur as low, poorly drained areas.

The surface, 6 to 7 inches in depth, varies from a brown silt loam with a gray cast to a grayish brown, sandy silt loam. The subsurface extends to a depth of 18 to 20 inches and is a floury, friable, gray silt loam with some streaks and splotches of yellow. The upper portion of the subsoil, which is a plastic, compact, mottled, grayish drab clay containing brownish red iron concretions, extends to a depth of about 38 inches. Below this stratum of "tight" clay, a friable, drabbish yellow, silty clay loam containing bright red iron concretions occurs.

Management.—The acidity tests indicate that this type is either neutral or only slightly acid. However, unless it is definitely known that the land does not need lime, it is suggested that the county farm adviser be consulted or that the assistance of the Experiment Station be secured. The areas of the type occurring along Edwards river should respond to fertilizer treatment in a manner very similar to the response of slightly undulating Brown Silt Loam. The poorly drained areas occurring in the Mississippi river terrace are very sensitive to unfavorable moisture conditions, and it is questionable whether any fertilizer treatment will cause sufficient increase in yield to pay for its cost unless the drainage is first improved. The trial of about 300 pounds of acid phosphate or of basic slag or half that amount of steamed bone meal, per acre, after plowing and before working down the seed bed for wheat, is suggested. If this is done and sweet clover is seeded in the wheat to be plowed down for corn the following spring, satisfactory crops should result unless unfavorable moisture conditions limit the yields on the poorly drained areas.

Yellow-Gray Silt Loam (1534)

Nearly all the areas of Yellow-Gray Silt Loam, Terrace, are found along Edwards river and Pope creek. The topography varies from flat to undulating, depending on the amount of erosion that has taken place.

The surface, which is about 5 inches in depth, varies in color from a yellowish brown to a yellowish gray, and in texture from a friable silt loam to a fine sandy silt loam. The subsurface, extending to 19 inches in depth, is a yellow, fine sandy loam. The subsoil below 19 inches is a medium, plastic yellow silt loam, changing to a bright yellow silt loam at 36 or 38 inches. This lower portion of the subsoil is splotched with bright red iron concretions.

Management.—The recommendations made for the management of Yellow-Gray Silt Loam, Upland (534), page 14, apply to this type.

Yellow-Gray Sandy Loam (1564)

Yellow-Gray Sandy Loam, Terrace, occurs, for the most part, along the lower courses of Pope creek and Edwards river. It covers only 2.32 square miles.

The surface is about 7 inches in depth and varies from a brownish yellow to yellowish gray, fine sandy loam. The subsurface, extending to about 18 inches in depth, is a mottled, yellow, fine sandy loam. The subsoil to a depth of 34 inches, is a fairly compact, yellow silt loam. Below 34 inches, it is a friable, mottled, yellow silt loam splotched with red iron concretions.

Management.—The recommendations made for Yellow-Gray Fine Sandy Loam, Upland (874), page 16, apply to this type.

Black Clay Loam (1520)

Black Clay Loam, Terrace, is a minor type in this county. It occupies 205 acres and is found only in small tracts. The topography is flat.

The surface soil, which is about 6 inches deep, is a plastic, black clay loam. The subsurface is a plastic, drabbish black to drab, clay loam. From 17 inches down, the subsoil is a plastic, drab clay, splotched with yellow, and below 34 inches, a drabbish blue clay occurs. There are no indications of the presence of alkali or carbonates but acidity tests indicate that limestone is not needed

Management.—The reader is referred to the discussion of the management of Black Clay Loam, Upland (520), page 14, for suggestions regarding the management of this type.

(d) and (e) SWAMP AND BOTTOM-LAND SOILS[1]

The group designated as Swamp and Bottom-Land soils includes the soils along the streams tributary to the Mississippi and the large area in the Mississippi river bottom proper. The soil is an alluvial formation and is, or has been within recent times, subject to overflow. The Mississippi river bottom land has been practically all leveed, and at the present time very little of the area is subject to overflow.

Deep Brown Silt Loam (1326, 1426)

Deep Brown Silt Loam occurs along the small streams as overflow land, and also in the Mississippi bottom.

The surface, extending to a depth of 5 inches, varies from a brown silt loam to a brown, fine sandy silt loam. The subsurface to about 22 inches in depth varies from a friable, mottled, brownish yellow, fine sandy silt loam to a brownish yellow silt loam. The subsoil varies from a somewhat compact, yellowish gray, silt loam to a somewhat compact, grayish yellow, silty clay loam.

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[1] On the soil map of Mercer county, the Swamp and Bottom-Land soils are divided into two groups, the Old and the Late. The basis for this grouping was the supposed length of time which has elapsed since the soil material forming the soils of the two groups was deposited. Subsequent investigations, however, makes it appear that this grouping was not well founded, because the maturity of these soils as revealed by the character of their profiles frequently does not correspond to their supposed age as determined by the length of time which is thought to have elapsed since the soil material forming them was deposited. For this reason the separation of Swamp and Bottom-Land soils into the two groups, Old and Late, is disregarded in the following discussion.

Management.—The portions of this type which are no longer subject to overflow are becoming acid. About 2 tons of limestone per acre is required on these areas to grow sweet clover. The type is well supplied with the elements of plant food and probably will not respond profitably to fertilizer treatment. Attention should be given to increasing the organic-matter content in the nonoverflow areas, particularly by plowing down leguminous organic matter, preferably sweet clover.

Mixed Loam (1354, 1454)

Mixed Loam is found along the small streams in the deep loess areas or in locations where conditions were such that much mixed material was deposited. This type cannot be adequately described because of its variations. It is mapped as Mixed Loam because it is made up of a mixture of several types which occur in areas too small to be mapped separately.

The surface varies in color from brown to yellowish gray and in texture from a silt loam to a sandy loam. The subsurface varies in a similar manner in texture, but usually has a yellowish gray color. At a depth of about 22 inches a brownish yellow to yellow, coarse sand is frequently found.

Management.—Much of the area covered by this type is subject to overflow and no treatment other than good tillage is recommended.

Black Clay Loam (1320)

Black Clay Loam, Bottom Land, which occupies about 230 acres of the county, is located in the basin of Henderson creek.

The surface, which is about 7 inches in depth, is a plastic, black clay loam. The subsurface, extending to a depth of about 15 inches, is a plastic, drabbish, black clay loam. The subsoil is a drab clay loam or clay.

Management.—This type is alkaline, as shown by the presence of snail shells. Thoro underdrainage should be provided and fresh organic matter should be plowed down at frequent intervals. If corn shows injury from the alkali, this difficulty may be lessened or entirely overcome by plowing down second-year sweet clover in the spring. The sweet clover should be plowed at least two weeks before corn planting time. The use of 75 to 100 pounds per acre of a potash salt at the time of, or just before, planting corn will counteract the injurious effects of the alkali.

Drab Clay (1415)

Drab Clay is found in the Mississippi river bottom north of New Boston. In topography it is flat, and it is difficult to farm both in wet and dry weather because of its fine texture. Since dredges have been built and pumping stations established, the water-table level has been lowered so that nearly all of the area can now be farmed.

The surface, which is about 6 inches in depth, varies from a very plastic, drab clay loam to a drab clay. The subsurface to about 20 inches in depth is a heavy, plastic, fairly compact, drab clay. The subsoil is also a very heavy,

plastic, drab clay, being somewhat of a "water logged" soil. Some fine sand is mixed with the clay below a depth of 36 to 40 inches.

Management.—This soil does not need lime and is well supplied with the elements of plant food, excepting nitrogen. The only way to improve its unfavorable physical properties is to be careful not to work it when too wet or too dry, and to make frequent additions of fresh organic matter. This type is productive but requires careful management to prevent its getting into very bad physical condition.

Drab Clay Loam (1421)

Drab Clay Loam is found in the bottom land in conjunction with Drab Clay. It has the same topography and similar drainage as Drab Clay.

The surface is about 4 inches in depth and varies from a heavy brown clay loam to a plastic drab clay loam. The subsurface is a plastic, drab clay loam, which changes gradually at about 22 inches to a plastic, grayish drab, clay subsoil.

Management.—The recommendations for management made for the preceding type, Drab Clay (1415), apply to this type. It is an easier soil to work than Drab Clay; however, it very easily gets into bad physical condition unless it is carefully handled and the organic-matter content is maintained.

Brown Sandy Loam (1460)

Brown Sandy Loam, Bottom Land, occurs in scattered areas thruout the Mississippi bottom and along Pope creek in the vicinity of Keithsburg. It is undulating in topography and is usually 3 or 4 feet higher than the surrounding soil areas. This type is a favorite for locating farm buildings because it is better drained and less muddy than surrounding areas. The Brown Sandy Loam along Pope creek is of a different origin from that occurring in the Mississippi bottom, being formed from material washed down from the upland lying to the east.

The surface, which is about 5 inches in depth, is a coarse-grained, brown sandy loam. The subsurface and subsoil are practically indistinguishable and vary from yellowish brown to yellow, coarse-grained river sand.

Management.—Brown Sandy Loam, Bottom Land, is very similar to Brown Sandy Loam, Terrace (1560), and should be managed in the same way. The discussion of the management of this type is found on page 18.

Black Mixed Loam (1450)

Black Mixed Loam occupies only a small percentage of the area of the county, covering about 450 acres. It is flat in topography, swampy, and poorly drained.

The surface varies from 7 to 10 inches in depth. It is black in color and varies in texture from sandy loam to clay loam. The subsurface is drabbish black in color, gradually becoming more drab with increasing depth. Considerable variation occurs in the texture of both the subsurface and the subsoil.

Management.—This type is well supplied with all the elements of plant food and is not acid. It becomes a productive soil when drained.

Mixed Sandy Loam (1463)

Mixed Sandy Loam is of minor importance. Only 173 acres of it occur in Mercer county and it is found only in very small tracts.

This type varies in color and texture as do all "mixed" types. In the main, it is a sandy soil with a light brown surface and a yellow or yellowish brown subsurface and subsoil. The type has been formed by the sandy material washing into low places. Frequently the original floor of the old pond or slough is found at less than 40 inches below the present surface.

Management.—This type should be handled in the same way as Mixed Loam (1354, 1454), and the reader is referred to the discussion on page 21.

Deep Peat (1401)

The total area of Deep Peat in Mercer county is very small, comprizing only 64 acres. It occurs in narrow strips bordering the sand terrace; its formation resulted from the continuously wet condition produced by seepage water from the terrace.

The peat is black and well decomposed. It rests on drab clay, which occurs at a depth of 34 to 42 inches below the surface.

Management.—Good drainage should be provided. This can be effected on most of the areas, as the clay is near enough to the surface to provide a bed for the tile. Peat is usually deficient in potassium, and it has been found profitable to supply this element in the form of a potash salt in amounts of 100 to 200 pounds per acre for the corn crop.

Muck On Clay (1413)

Only 51 acres of Muck On Clay are found in Mercer county. It occurs in connection with the Deep Peat and was formed in the same way but contains a higher percentage of clay particles. It is a black, slightly plastic, highly organic material to a depth of about 20 inches, where it rests on black clay. At a depth of about 34 inches, the clay becomes drab in color and is very plastic.

Management.—Drainage is probably all that is needed to make this type productive.

River Sand (1480)

River Sand occurs as small sand ridges usually formed by wind action. It is a soil type of small importance. There are only 51 acres in the county and it is of low agricultural value. It should be handled in the same way as Dune Sand (1581), page 18.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to intelligently interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification used.

The type is the unit of classification and each type has definite characteristics. In establishing types, the following factors are taken into account: the character of the horizons composing the soil as to depth and thickness, physical composition, structure, organic-matter content, color, reaction, and carbonate content; the topography; the native vegetation; and the geological origin of the soil.[1]

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made whenever the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

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[1] Since some of the terms used in designating the factors which are taken into account in establishing soil types are technical in nature, the following explanations are introduced:

Horizon. A layer or stratum of soil which differs discernibly from those adjacent in color, texture, structure, chemical composition, or a combination of these characteristics, is called an horizon.

Depth and Thickness. The horizons or layers which make up the soil profile vary in depth and thickness. These variations are distinguishing features in the separation of soils into types.

Physical Composition. The physical composition, sometimes referred to as "texture," is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents: clay, silt, fine sand, sand, gravel, stones, and organic material.

Structure. The term "structure" has reference to the aggregation of particles within the soil mass and carries such qualifying terms as open, granular, compact.

Organic-Matter Content. The organic matter of soil is derived largely from plant tissue and it exists in a more or less advanced stage of decomposition. Organic matter constitutes the predominating constituent in certain soils of swampy formation.

Color. Color is determined to a large extent by the proportion of organic matter, but at the same time it is modified by the mineral constituents, especially by iron compounds.

Reaction. The term "reaction" refers to the chemical state of the soil with respect to acid or alkaline condition. It also involves the idea of degree, as strongly acid or strongly alkaline.

Carbonate Content. The carbonate content has reference to the calcium carbonate (limestone) present, which in some cases may be associated with magnesium or other carbonates. The depth at which carbonates are found may become a very important factor in determining the soil type.

Topography. Topography has reference to the lay of the land, as level, rolling, hilly, etc.

Native Vegetation. The vegetation or plant growth before being disturbed by man, as prairie grasses and forest trees, is a feature frequently recognized in determining soil types.

Geological Origin. Geological origin involves the idea of character of rock materials composing the soil as well as the method of formation of the soil.

Classifying Soil Types.—In the system of classification used, the types fall first into four general groups based upon their geological relationships; namely, upland, terrace, swamp and bottom land, and residual. These groups may be subdivided into prairie soils and timber soils, altho as a matter of fact this subdivision is applied in the main only to the upland group. These terms are all explained in the foregoing part of the report in connection with the description of the particular soil types.

Naming and Numbering Soil Types.—In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a more or less definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise type names which are adequately descriptive, because the profile of mature soils is usually made up of four or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "on," and when its depth exceeds 30 inches, by the word "over"; for example, Brown Silt Loam On Gravel, and Brown Silt Loam Over Gravel.

As a further step in systematizing the listing of the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been assigned an index number. The names of the areas together with their general location and their corresponding index numbers are given in the following list.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* comprizing three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciations
300 *Lower Illinoisan glaciation,* covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* found in the older or Illinoisan glaciation
1400 *Late river-bottom and swamp lands,* those of the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan

For further information regarding these geological areas the reader is referred to the general map published in Bulletins 123 and 193.

Another set of index numbers is assigned to the classes of soils as based upon physical composition. The following list contains the names of these classes with their corresponding index numbers.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy Loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the balance of the number designates the type. To illustrate: the number 1126 means Brown Silt Loam in the early Wisconsin glaciation, 434 means Yellow-Gray Silt Loam of the middle Illinoisan glaciation. These numbers are especially useful in designating very small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports in connection with the maps.

SOIL SURVEY METHODS

Mapping of Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. The field work is done by parties of two to four men each. The field season extends from early in April to Thanksgiving. During the winter months the men are engaged in preparing a copy of the soil map to be sent to the lithographer, a copy for the use of the county farm adviser until the printed map is available, and a third copy for use in the office in order to preserve the original official map in good condition.

An accurate base map for field use is necessary for soil mapping. These maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as the basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil type boundaries, together with the streams, roads, railroads, canals, town sites, and rock and gravel quarries are placed in their proper location upon the map while the mapper is on the area. With the rapid development of road improvement during the past few years, it is almost inevitable that some recently established roads will not appear on the published soil map. Similarly, changes in other artificial features will occasionally occur in the interim between the preparation of the map and its publication. The detail or minimum size of areas which are shown on the map varies somewhat, but in general a soil type if less than five acres in extent is not shown.

A soil auger is carried by each man with which he can examine the soil to a depth of 40 inches. An extension for making the auger 80 inches long is taken

by each party, so that the deeper subsoil may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by a speedometer or other measuring device, while distances in the field away from the roads are measured by pacing.

Sampling for Analysis—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. The samples for this purpose are usually taken in three depths; namely, 0 to 6⅔ inches, 6⅔ to 20 inches, and 20 to 40 inches, as explained in connection with the discussion of the analytical data on page 6.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. A fact of equal importance, not so generally recognized, is that they also differ in other characteristics such as response to fertilizer treatment and to management.

The soil is a dynamic, ever-changing, exceedingly complex substance made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, the soil cannot be considered as a reservoir into which a given quantity of an element or elements of plant food can be poured with the assurance that it will respond with a given increase in crop yield. In a similar manner it cannot be expected to respond with perfect uniformity to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance favorable for the growth of the higher plants and of the beneficial microorganisms. Good soil management under humid conditions involves the adoption of those tillage, cropping, and fertilizer treatment methods which will result in profitable and permanent crop production on the soil type concerned.

The following paragraphs are intended to state in a brief way some of the principles of soil management and treatment which are fundamental to profitable and continued productivity.

CROP REQUIREMENTS WITH RESPECT TO PLANT-FOOD MATERIALS

Ten different elements of plant food are essential for the growth and formation of every plant. These elements are: *carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, magnesium, calcium, and iron.* Some seasons in central Illinois are sufficiently favorable to allow the production of at least 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. When such crops, growing under favorable climatic and cultural conditions and uninjured by disease or insect pests, are not produced the failure is due to unfavorable soil conditions, which may result from poor drainage, poor physical condition, or from an actual deficiency in one or more of the elements of plant food.

TABLE A.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phos-phorus	Sulfur	Potas-sium	Magne-sium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain......	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat, straw.....	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain.......	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover.......	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs........	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain.......	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw........	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed.......	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay.......	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed.....	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay......	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay.......	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1] These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

Table A shows the requirements of some of our most common field crops with respect to the seven plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of any element removed from an acre of land by a crop of a given yield can easily be computed.

PLANT-FOOD SUPPLY

Of the ten elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and seven from the soil. *Nitrogen,* one of these seven elements obtained from the soil by all plants, may also be secured from the air by the class of plants known as legumes, in case the amount liberated from the soil is insufficient; but even these plants, which include only the clovers, peas, beans, and vetches among our common agricultural plants, are dependent upon the soil for the other six elements (phosphorus, potassium, magnesium, calcium, iron, and sulfur), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 420 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor

TABLE B.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	...	...
Sodium nitrate	310	...	...
Ammonium sulfate	400	...	...
Raw bone meal	80	180	...
Steamed bone meal	20	250	...
Raw rock phosphate	...	250	...
Acid phosphate	...	125	...
Potassium chlorid	...	...	850
Potassium sulfate	...	...	850
Kainit	...	...	200
Wood ashes[3] (unleached)	...	10	100

[1] See footnote to Table A.
[2] Young second year's growth ready to plow under as green manure.
[3] Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

of production, then we must look for some outside source of supply. Table B is presented for the purpose of furnishing information regarding the quantity of some of the more important plant-food elements contained in materials most commonly used as sources of supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of plant-food elements actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such elements as calcium and phosphorus, converting them into available forms for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral elements are liberated for

the benefit of the cereal crops which follow in the rotation. Moreover, as an effect of the deep-rooting habit of these legumes, mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and supplies calcium, thus encouraging the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the unavailable organic nitrogen into available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium compounds.

Organic Matter and Biological Action.—Organic matter may be supplied thru animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant-food materials than the 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the ratio of carbon to nitrogen. Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing available phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant-food elements by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant-food materials are concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than

this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter, and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement.

Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands. Remarkable success has been experienced with limestone used in conjunction with sweet clover in the reclamation of abandoned hill land which has been ruined thru erosion.

Amounts to Apply.—If the soil is acid, usually at least 2 tons per acre of ground limestone should be applied as an initial treatment. Continue to apply limestone from time to time according to the requirement of the soil as indicated by the tests described below, or until the most favorable conditions are established for the growth of legumes, using preferably at times magnesian limestone ($CaCO_3MgCO_3$), which contains both calcium and magnesium and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone ($CaCO_3$). On strongly acid soils, or on land being prepared for alfalfa, 4 or 5 tons per acre of ground limestone may well be used for the first application.

How to Ascertain the Need for Limestone.—One of the most reliable indications as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover and alfalfa. These crops do not thrive in acid soils. Their successful growth, therefore, indicates the lack of sufficient acidity in the soil to be harmful. In case of their failure to grow the soil should be tested for acidity as described below. A very valuable test for ascertaining the need of a soil for limestone is found in the potassium thiocyanate test for soil acidity. It is of value to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonate of calcium and magnesium. The natural occurrence of these carbonates in the

soil is sufficient assurance that no limestone is needed, and the acidity test will be negative. On lands which have been treated with limestone, however, the surface soil may give a positive test for carbonates, due to the presence of undecomposed pieces of limestone, and at the same time a positive test for acidity may be secured. Such a result means either that insufficient limestone has been added, or that it has not been in the soil long enough to entirely correct the acidity. In making these tests, it is desirable to examine samples of soil from different depths, since carbonates may be present, even in abundance, below a surface stratum that is acid. Following are the directions for making the tests:

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol (not denatured). When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. In testing, therefore, the sample should be about as dry as when the soil is in good tillable condition. The conditions for a prompt reaction require a temperature that is comfortably warm.

The Hydrochloric Acid Test for Carbonates. Make a shallow cup of a ball of soil and pour into it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of limestone or some other carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen usually costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for plant growth. These are the chemical and the biological fixation of the atmospheric nitrogen. Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of those legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for purposes other than the fixation of atmospheric nitrogen, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen will ever be able to replace the simple method

of obtaining atmospheric nitrogen by growing inoculated legumes in the production of our great grain and forage crops.

It may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpea hay contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of the soil is dependent upon the origin of the soil. The removal of phosphorus by continuous cropping slowly reduces the amount of this element in the soil available for crop use, unless its addition is provided for by natural means, such as overflow, or by agricultural practices, such as the addition of phosphatic fertilizers and rotations in which deep-rooting, leguminous crops are frequently grown.

It should be borne in mind in connection with the application of phosphate, or of any other fertilizing material, to the soil, that no benefit can result until the need for it has become a limiting factor in plant growth. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different materials containing phosphorus which are applied to land as fertilizer. The more important of these are bone meal, acid phosphate, natural raw rock phosphate, and basic slag. Obviously that carrier of phosphorus which gives the most economical returns, as considered from all standpoints, is the most suitable one to use. Altho this matter has been the subject of much discussion and investigation the question still remains unsettled. Probably there is no single carrier of phosphorus that will prove to be the most economical one to use under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

Bone meal, prepared from the bones of animals, appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the

phosphorus, a considerable percentage of nitrogen which adds a useless expense if the material is purchased only for the sake of the phosphorus. As a source of phosphorus, steamed bone meal is preferable to raw bone meal. Steamed bone meal is prepared by extracting most of the nitrogenous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate containing about 10 to 12 percent of the element phosphorus.

Acid phosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. Acid phosphate also contains besides phosphorus, sulfur, which is likewise an element of plant food. The phosphorus in acid phosphate is more readily available for absorption by plants than that of raw rock phosphate. Acid phosphate of good quality should contain 6 percent or more of the element phosphorus.

Rock phosphate, sometimes called floats, is a mineral substance found in vast deposits in certain regions. The phosphorus in this mineral exists chemically as tri-calcium phosphate and a good grade of the rock should contain 12½ percent, or more, of the element phosphorus. The rock should be ground to a powder, fine enough to pass thru a 100-mesh sieve, or even finer.

The relative cheapness of raw rock phosphate, as compared with the treated or acidulated material, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in this form than in the form of acid phosphate, the ratio being, under the market conditions of the past several years, about 4 to 1. That is to say, under these market conditions, a dollar will purchase about four times as much of the element phosphorus in the form of rock phosphate as in the form of acid phosphate, which is an important consideration if one is interested in building up a phosphorus reserve in the soil. As explained above, more very carefully conducted comparisons on various soil types under various cropping systems are needed before definite statements can be given as to which form of phosphate is most economical to use under any given set of conditions.

Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag phosphate is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore it tends to influence the soil reaction.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating the phosphorus from raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using acid phosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount

to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, which are silt loams and clay loams, are well stocked with potassium, altho it exists largely in a slowly soluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be supplied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of common soils are concerned, that, with a few exceptions, the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part, perhaps, because the potassium removed in the crops is mostly returned in the manure if properly cared for, and perhaps in larger part because the decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no limiting element of plant food.

In considering the conservation of potassium on the farm it should be remembered that in average live-stock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in livestock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by the actual crop requirements for plant food, magnesium and calcium are more limited in some Illinois soils than potassium. But with these elements we must consider also the loss by leaching.

The annual loss of limestone from the soil depends, of course, upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of lime materials from the soil, it is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

Limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur

in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply to conditions in Illinois.

Physical Improvement of Soils

In the management of most soil types, one very important matter, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, slightly retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is undergoing destruction during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, cornstalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and cornstalks should be turned under, and not burned. There is considerable evidence indicating that on some soils undecomposed straw applied in excessive amount may be detrimental. Probably the best practice is to apply the straw as a constituent of well-rotted stable manure. Perhaps no form of organic matter acts more beneficially in producing good tilth than cornstalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of cornstalks is one and one-half times that of a ton of manure, and a ton of dry cornstalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the cornstalks during the winter and often rather late in the spring after the frost is out of the ground. This trampling by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too

late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The effect becomes worse if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including, for the reasons discussed above, a liberal use of legumes. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations, applicable to the corn belt, which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth Year —Wheat (with clover), or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in live-stock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be seeded four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year	—Corn	*First year*	—Corn
Second year	—Wheat or oats (with clover)	*Second year*	—Corn
Third year	—Clover	*Third year*	—Wheat or oats (with clover)
Fourth year	—Wheat (with clover)	*Fourth year*	—Clover

First year	—Corn	*First year*	—Wheat (with clover)
Second year	—Cowpeas or soybeans	*Second year*	—Clover
Third year	—Wheat (with clover)	*Third year*	—Corn
Fourth year	—Clover	*Fourth year*	—Oats (with clover)

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year	—Corn	*First year*	—Wheat (with clover)
Second year	—Oats or wheat (with clover)	*Second year*	—Corn
Third year	—Clover	*Third year*	—Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year	—Oats or wheat (with sweet clover)
Second year	—Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. Or, in some cases, it may become desirable to divide the acreage of small grain and grow in the same year more than one kind. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover, especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(*Results from Experiment Fields on Soil Types Similar to Those Occurring in Mercer County*)

In the earlier reports of this series it was the practice to incorporate in the body of the report the results of certain experiment fields, for the purpose of illustrating the possibilities of improving the soil of various types. The information carried by such data must, naturally, be considered more or less tentative. As the fields grow older new facts develop, which in some instances may call for the modification of former recommendations. It has therefore seemed desirable to separate this experiment field data from the more permanent information of the soil survey, and embody the same in the form of a supplement to the soil report proper, thus providing a convenient arrangement for possible future revisions as further data accumulate.

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the majority are still in operation. It is the present purpose to report the summarized results from certain of these fields located on types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Two Farming Systems Provided

On many of the fields the treatment provides for two distinct systems of farming, livestock farming and grain farming.

In the livestock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as cornstalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It is the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the livestock system.

Definite Crop Rotations Followed

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Standard Soil Treatments Used

The treatment applied to the plots has, for the most part, been standardized according to a rather definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grain to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, the equivalent of 200 pounds of kainit. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

TABLE 1.—URBANA FIELD, MORROW PLOTS

Crop Yields in Soil Experiments—Bushels or (tons) per acre

Year	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
		Corn	Corn	Oats	Corn	Oats	Clover
1879–87	None........	....	....	....	....	....	....
1888	None........	54.3	49.5	....	....	48.6	....
1889	None........	43.2	....	37.4	....	....	(4.04)
1890	None........	48.7	54.3	....	....	....	(1.51)
1891	None........	28.6	33.2	....	....	....	(1.46)
1892	None........	33.1	....	37.2	70.2	....	....
1893	None........	21.7	29.6	....	34.1	....	....
1894	None........	34.8	....	57.2	....	65.1	....
1895	None........	42.2	41.6	....	....	22.2	....
1896	None........	62.3	....	34.5	....	....	....
1897	None........	40.1	47.0	....	....	....	....
1898	None........	18.1	....	....	....	....	....
1899	None........	50.1	44.4	....	53.5	....	....
1900	None........	48.0	....	41.5	....	....	....
1901	None........	23.7	33.7	....	34.3	....	....
1902	None........	60.2	....	56.3	....	54.6	....
1903	None........	26.0	35.9	....	....	....	(1.11)
1904	None........	21.5	....	17.5	55.3	....	....
1904	MLP........	17.1	....	25.3	72.7	....	....
1905	None........	24.8	50.0	....	....	42.3	....
1905	MLP........	31.4	44.9	....	....	50.6	....
1906	None........	27.1	....	34.7	....	....	(1.42)[1]
1906	MLP........	35.8	....	52.4	....	....	(1.74)[1]
1907	None........	29.0	47.8	....	80.5	....	....
1907	MLP........	48.7	87.6	....	93.6	....	....
1908	None........	13.4	....	32.9	....	40.0	....
1908	MLP........	28.0	....	45.0	....	44.4	....
1909	None........	26.6	33.0	....	....	....	(.65)[2]
1909	MLP........	31.6	64.8	....	....	....	(1.73)[3]
1910	None........	35.9	....	33.8	58.6	....	....
1910	MLP........	54.6	....	59.4	83.3	....	....
1911	None........	21.9	28.6	....	....	20.6	....
1911	MLP........	31.5	46.3	....	....	38.0	....
1912	None........	43.2	....	55.0	....	....	16.3[1]
1912	MLP........	64.2	....	81.0	....	....	20.0[1]
1913	None........	19.4	29.2	....	33.8	....	....
1913	MLP........	32.0	25.0	....	47.8	....	....
1914	None........	31.6	....	33.6	....	39.6	....
1914	MLP........	39.4	....	58.2	....	60.4	....
1915	None........	40.0	49.0	....	....	....	24.2[1]
1915	MLP........	66.0	81.2	....	....	....	27.1[1]
1916	None........	11.2	....	37.5	27.8	....	....
1916	MLP........	10.8	....	64.7	40.6	....	....
1917	None........	40.0	48.4	....	....	68.4	....
1917	MLP........	67.0	81.4	....	....	86.9	....
1918	None........	13.6	....	27.2	....	....	(2.58)
1918	MLP........	32.6	....	59.3	....	....	(4.04)
1919	None........	24.0	30.8	....	52.2	....	....
1919	MLP........	43.4	66.2	....	70.8	....	....
1920	None........	28.2	....	37.2	....	52.2	....
1920	MLP........	54.4	....	51.6	....	69.7	....
1921	None........	19.8	30.6	....	....	....	(.26)[4]
1921	MLP........	42.2	68.4	....	....	....	(1.33)[5]
1922	None........	24.6	....	39.3	49.2	....	....
1922	MLP........	39.4	....	55.8	65.3	....	....
1923	None........	15.0	17.2	....	....	53.4	....
1923	MLP........	31.4	46.4	....	....	66.6	....
1924	None........	28.0	....	36.0	....	....	(1.83)
1924	MLP........	38.0	....	68.5	....	....	(4.42)

[1] Soybeans. [2] In addition to the hay, .64 bushel of seed was harvested. [3] In addition to the hay, 1.17 bushels of seed were harvested. [4] In addition to the hay, .53 bushel of seed was harvested. [5] In addition to the hay, .85 bushel of seed was harvested.

EXPERIMENTS ON BROWN SILT LOAM

Several experiment fields have been conducted on Brown Silt Loam at various locations in Illinois. Those located at the University have been in operation the longest and they serve well to illustrate the principles involved in the maintenance and improvement of this type of soil.

The Morrow Plots

So far as known, the oldest soil experiment field in the United States is located on Brown Silt Loam of the early Wisconsin glaciation, on the campus of the University of Illinois. According to official records the experiments on this field were authorized in 1879. The plots are now known as the Morrow Plots, in honor of George E. Morrow, who was at that time Professor of Agriculture.

The Morrow series now consists of three plots divided into halves, and the halves are subdivided into quarters. On one plot, corn is grown continuously; on the second, corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904. Besides farm manure, phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. At the same time the rate of subsequent application of both forms of phosphorus was reduced to one-fourth the quantity, or to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per year. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre.

Table 1 gives the yearly records of the crop yields from the Morrow plots, and Table 2 presents the results in summarized form.

Summarizing the data from these Morrow plots into two periods, with the second period beginning in 1904, when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the untreated, continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oats production, while the averages for the three-year system show an increase in corn yield and decreases in oats and

TABLE 2.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY

Average Annual Yields—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover
		16 crops	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
1888 to 1903	None........	39.7	41.0	44.0	48.0	47.6	(2.03)
		21 crops	*10 crops*	*11 crops*	*7 crops*	*7 crops*	*7 crops*[1]
1904 to 1924	None........	25.7	36.5	35.0	51.1	45.2	(1.71)
	MLP........	39 9	61.2	56.5	67.7	59.5	(2.86)

[1]Including all legume crops evaluated as clover hay.

clover. Unfortunately the numbers of crops included in these last averages are too small to warrant positive conclusions.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

The Davenport Plots

Another set of plots on the University campus at Urbana, forming a more extensive series than the Morrow plots, but of more recent origin, are the Davenport plots. Here provision is made for each crop in the rotation to be represented every year. These plots were laid out in 1895, but special soil treatment was not begun until 1901. They now comprize five series of ten plots each, and each series constitutes a "field" in a crop rotation system.

From 1901 to 1911 three of the series were in a three-year rotation system of corn, oats, and clover, while the remaining two series rotated in corn and oats. In 1911 these two systems were combined into a five-series field, with a crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field. The alfalfa occupies one series during a rotation of the other four crops, shifting to another series in the fifth year, thus completing the cycle of all series in twenty-five years.

The soil treatment applied to these plots has been as follows:

Legume cover crops were seeded in the corn at the last cultivation on Plots 2, 4, 6, and 8, from 1902 to 1907, but the growth was small and the effect, if any, was to decrease the returns from the regular crops. Crop residues (**R**) have been returned to these same plots since 1907. These consist of stalks and straw, and all legumes except alfalfa hay and the seed of clover and soybeans. Beginning in 1918 a modification of the practice was made in that one cutting of the red clover crop is harvested as hay. In conjunction with these residues a catch crop of sweet clover grown with the wheat is plowed under.

Manure (**M**) was applied preceding corn, at the rate of 2 tons per acre in 1905, 1906, and 1907; subsequently as many tons have been applied as there have been tons of air-dry produce harvested from the respective plots.

Lime (**L**) was applied on Plots 4 to 10 at the rate per acre of 250 pounds of air-slaked lime in 1902, and 600 pounds of limestone in 1903. No further application was made until 1911, when the system of cropping was changed. Since that time applications of limestone have been made at the yearly rate of one-half ton per acre.

Phosphorus (**P**) was applied on Plots 6 to 9 at the yearly rate of 25 pounds per acre in 200 pounds of steamed bone meal; but beginning with 1908 rock phosphate at the rate of 600 pounds per acre per year was substituted for the bone meal on one-half of each of these plots. These applications continued until 1918, when adjustments were begun, first to make the rate of application of rock phosphate four times that of the bone meal, and finally to reduce the amounts of these materials to 200 pounds of rock phosphate and 50 pounds of bone meal per acre yearly. The usual practice has been to apply and plow under at one time all phosphorus and potassium required for the rotation.

Potassium (**K**) has been applied on Plots 8 and 9 in connection with the bone meal and rock phosphate, at the yearly rate of 42 pounds per acre, and mainly as potassium sulfate.

On Plot 10 about five times as much manure and phosphorus are applied as on the other plots, but this "extra heavy" treatment was not begun until 1906, only the usual amounts of lime, phosphorus, and potassium having been applied in previous years. The purpose in making these heavy applications is to try to determine the climatic possibilities in crop yields by removing the limitations of inadequate amounts of the elements of plant food.

It will be observed that the applications described above provide for the two rather distinct systems of farming already described. The *grain system*, in which animal manure is not produced and where the organic matter is provided by the direct return to the soil of crop residues along with legumes, is exemplified in Plots 2, 4, 6, and 8; and the *livestock system*, in which farm manure is utilized for soil enrichment, is represented in the corresponding Plots 3, 5, 7, and 9.

Table 3 shows a summary of the results obtained on the Davenport plots beginning with the year 1911, when the present cropping system was introduced.

When used in conjunction with phosphorus, the crop residues and the manure appear about equally effective; but where phosphorus is not applied, manure has been decidedly more effective than residues, under the conditions of the experiment. It should be observed, however, in this connection, that the plowing under of clover is a very essential feature of the residues system, and that, as a matter of fact during the fourteen years there were five clover failures, when soybeans were substituted. Perhaps with a more reliable biennial legume than red clover, the results would have been more favorable for this system.

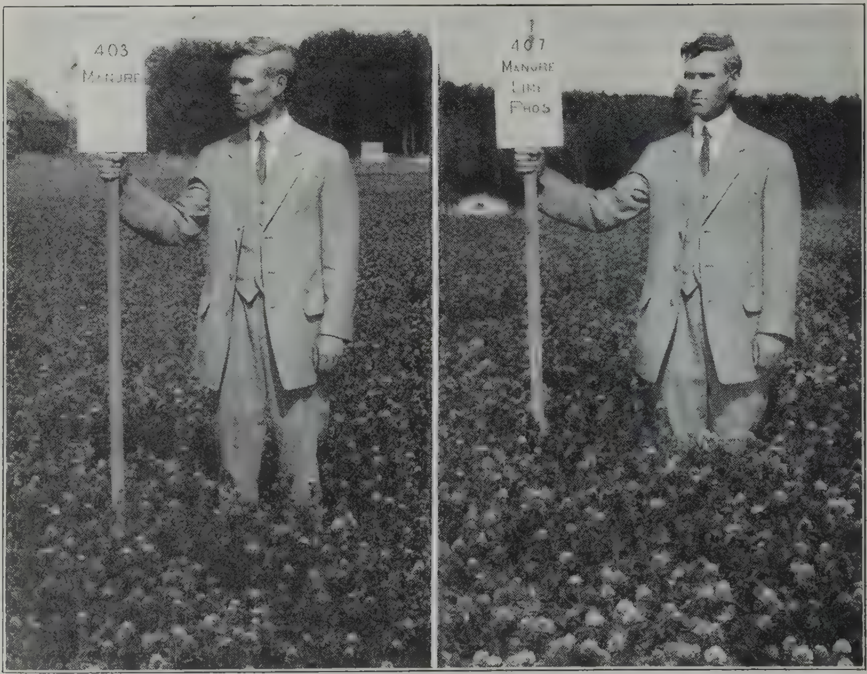
By comparing Plots 2 and 3 with Plots 4 and 5, it is found that limestone has had a beneficial effect on all crops. What the financial profit amounts to depends obviously upon the market value of the crops and the cost of the limestone.

TABLE 3.—URBANA FIELD, DAVENPORT PLOTS

Average Annual Yields 1911-1924—Bushels or (tons) per acre

Plot	Soil treatment applied	Corn *14 crops*	Oats *15 crops*[1]	Wheat *14 crops*	Clover *9 crops*		Soybeans *5 crops*	Alfalfa *12 crops*
1	0	53.1	53.2	26.6	(1.96)	....	(1.47)	(2.64)
2	R	53.8	54.5	29.3	(.40)	1.23	19.8	(2.76)
3	M	64.3	62.6	29.9	(2.25)		(1.62)	(2.71)
4	RL	62.9	57.8	32.4	(.58)	1.40	20.3	(2.99)
5	ML	69.0	64.8	34.8	(2.78)		(1.67)	(3.24)
6	RLP	69.8	71.3	42.2	(.72)	1.53	23.5	(4.10)
7	MLP	71.2	70.7	41.1	(3.39)		(1.97)	(4.19)
8	RLPK	70.9	73.1	40.0	(.73)	1.20	25.5	(4.30)
9	MLPK	69.0	72.3	40.0	(3.39)		(2.20)	(4.22)
10	Mx5LPx5	65.1	72.0	40.1	(3.11)	....	(2.22)	(4.26)

[1]Including a nurse crop of oats, grown with alfalfa seeding in 1924.



Manure
Yield: 1.43 tons per acre

Manure, limestone, phosphorus
Yield: 2.90 tons per acre

FIG. 1.—CLOVER ON THE DAVENPORT PLOTS IN 1913

Comparing Plots 4 and 5 with Plots 6 and 7, respectively, there is found in all cases an increase in crop yield as a result of adding phosphorus. The effect on wheat is especially pronounced. Where limestone and phosphorus are applied in addition to the crop residues, an increase of 15.6 bushels of wheat, over the yield of the untreated land, has been obtained as a fourteen-year average.

The effect of adding potassium to the treatment is of much interest. Plots 8 and 9 are similar to Plots 6 and 7, respectively, except that potassium has been applied to the former. The small gains appearing in certain cases are counterbalanced by losses in others, and on the whole, potassium treatment has not been profitable on these plots.

No benefit appears as the result of the extra-heavy applications of manure and phosphorus on Plot 10. In fact the corn yields are noticeably less here than on the plots receiving the normal applications of these materials.

The University South Farm

On the University South Farm, at Urbana, several series of plots devoted primarily to variety testing and other crop-production experiments are so laid out as to show the effects of certain soil treatments that have been applied. Several different systems of crop rotation are employed and the crops are so handled as to exemplify the two general systems of farming, grain and livestock.

TABLE 4.—URBANA FIELD, SOUTH FARM
SOUTHWEST ROTATION: SERIES 100, 200, 400[1]
Average Annual Yields 1908-1919—Bushels or (tons) per acre

Soil treatment applied[6]	Corn 9 crops	Oats[3] 9 crops	Wheat[3] 8 crops	Clover[4] 3 crops	Soybeans[2] 7 crops
R	50.8	48.1	26.4	1.11	15.5[5]
RP	62.3	51.9	41.0	1.05	17.3[5]
RPL	60.5	57.2	41.8	.64	16.4[5]
M	57.6	52.2	28.5	(2.00)	(1.27)
MP	64.3	55.4	43.1	(2.86)	(1.51)
MPL	64.1	59.6	43.9	(1.77)	(1.58)
Gains for Phosphate					
RP over R	11.5	3.8	14.6	−.06	1.8
MP over M	6.7	3.2	14.6	(.86)	(.24)
Gains for Limestone					
RPL over RP	−1.8	5 3	.8	−.41	−.9
MPL over MP	−.2	4.2	.8	(−.09)	(−.07)

[1]Results from Series 300 are omitted on account of variation in soil type.
[2]Soybeans when clover fails.
[3]Only seven crops with limestone.
[4]Only one crop with limestone.
[5]Average of five crops.
[6]All phosphorus plots received ½ ton per acre of limestone in 1903.

The results presented in Table 4 are those of the Southwest rotation.

Residues plowed under
Yield: 35.2 bushels per acre

Residues and rock phosphate
Yield: 50.1 bushels per acre

FIG. 2.—WHEAT ON THE UNIVERSITY SOUTH FARM IN 1911

The cropping program on this series includes wheat, corn, oats, and clover, with the substitution of soybeans when clover fails. This rotation system is regarded as one well adapted to this type of soil under Illinois conditions.

In looking over the results in Table 4 it is observed that the yields in general do not run quite so high in the residues system as in the manure system; but as observed in the case of the Davenport series mentioned above, the residues system has been handicapped to some extent thru frequent clover failure.

The results showing the effect of phosphorus treatment are of interest. As the carrier of phosphorus rock phosphate has been employed. The figures show an increase in yield wherever phosphate has been applied except in the single case of the clover seed. In the corn, wheat, and clover the increase is very pronounced.

Limestone has been used on this field only in conjunction with phosphate, and it seems to have produced little or no effect. The small differences appearing as the result of adding limestone can well be ascribed to the natural plot variation. The comparisons, may be somewhat impaired, however, due to a possible residual effect of a small application of limestone made in 1903 to all the phosphate plots.

The Aledo Field

An experiment field on Brown Silt Loam is located in Mercer county just west of Aledo. This field has been in operation since 1910. From its physical aspects this field should be well adapted to experimental work, the land being unusually uniform in topography and in soil profile.

The diagram presented as Fig. 4 shows the arrangement of plots on the Aledo field. There are two general systems of plots and they are designated as the major and the minor systems. The major system comprizes four series (numbered 100, 200, 300, 400) made up of 10 plots each. The plots were handled substantially as described for standard treatment until 1922, when a number of changes to be mentioned below were introduced. The rotation practiced was wheat, corn, oats, and clover, until 1923, when the cropping program also was modified.

The yields of all crops on this system of plots since the beginning of the experiments up to 1923 are recorded in Table 5, and a summary of the results is presented in Table 6. This summary shows the average annual yields obtained for the period beginning when complete soil treatment came into sway and ending with the year 1922, after which the crop rotation was changed.

It will be noted that soybeans have been substituted several times for red clover when the latter failed. For the present purpose only the grain crops are considered in the summary. The lower section of Table 6 gives comparisons in terms of crop increases intended to indicate the effect of the different fertilizing materials applied.

In looking over these results we may observe first the beneficial effect of animal manure in all crops, but especially marked in the corn. This suggests the advisability of carefully conserving and regularly applying all stable manure. Residues, alone, have as yet shown little effect.

Where limestone has been applied, there is usually a small increase in

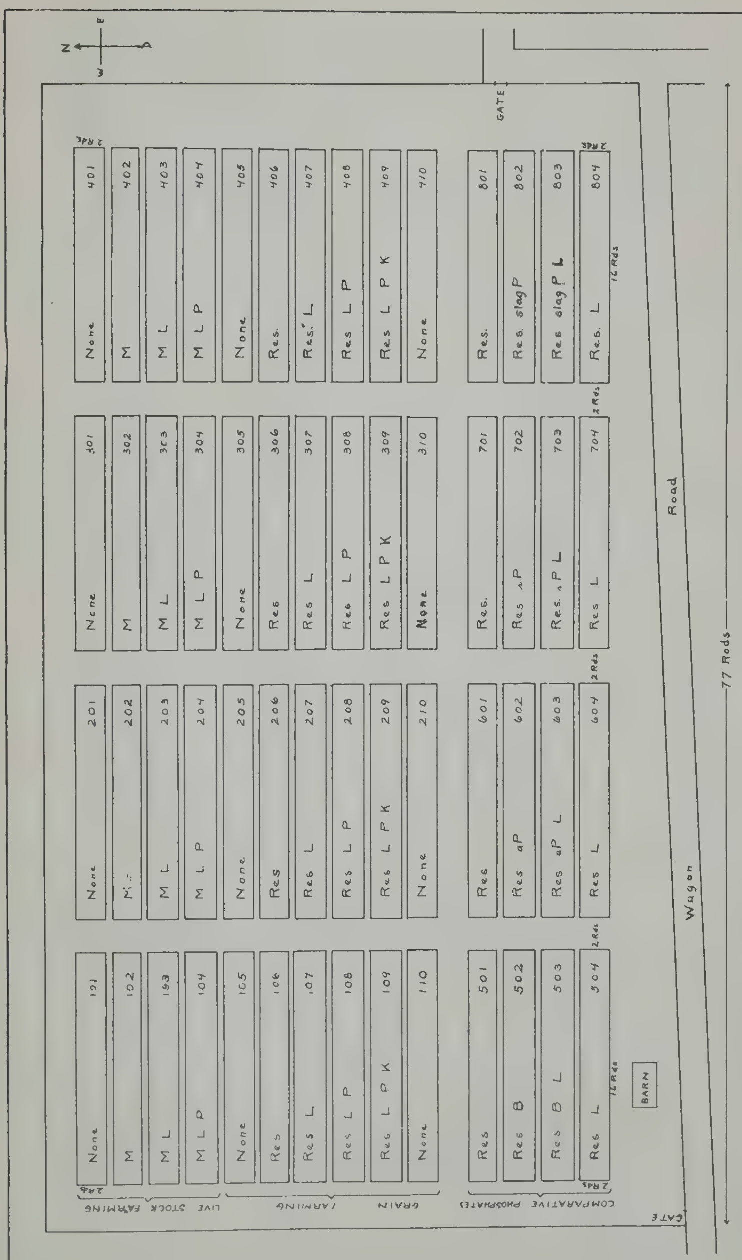


FIG. 3.—DIAGRAM SHOWING ARRANGEMENT OF PLOTS ON THE ALEDO EXPERIMENT FIELD

TABLE 5.—ALEDO FIELD

ROTATION: WHEAT, CORN, OATS, CLOVER

Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1910 Oats[5]	1911 Corn[1]	1912 Oats[2]	1913 Clover[2]	1914 Wheat[3]	1915 Corn	1916 Oats	1917 Clover	1918 Wheat	1919 Corn	1920 Oats	1921 Soybeans	1922 Wheat	1923 Corn
101	0..........	60.2	69.3	49.2	(3.02)	27.0	52.8	51.9	(1.46)	32.6	60.9	67.5	21.3	28.4	47.5
102	M..........	37.5	68.1	38.1	(3.16)	29.2	67.7	62.5	(2.23)	32.2	85.5	73.4	16.2	29.2	75.9
103	ML.........	60.6	67.6	40.8	(3.29)	31.8	67.9	65.8	(2.24)	34.5	75.6	65.8	15.1	32.5	80.5
104	MLP.......	60.8	65.1	41.4	(3.55)	34.6	72.2	71.9	(2.38)	39.2	77.1	84.4	13.1	35.1	78.8
105	0..........	48.1	70.7	40.3	2.33	30.0	56.8	56.2	.50	31.8	62.2	84.2	15.9	25.4	64.9
106	R..........	55.0	64.6	40.6	2.42	30.6	58.3	52.5	.58	35.7	71.7	71.7	15.1	25.0	74.2
107	RL.........	53.4	66.8	45.0	2.67	33.1	61.5	57.8	1.25	38.6	79.4	72.3	17.6	30.7	89.0
108	RLP........	46.1	69.2	46.9	1.92	36.1	69.1	60.0	1.75	43.7	78.6	77.7	19.4	34.8	87.8
109	RLPK......	61.4	65.8	43.1	2.50	32.7	63.1	62.8	1.33	40.7	78.0	79.7	19.8	34.6	88.7
110	0..........	53.1	67.1	45.2	(3.06)	26.8	55.6	58.1	(1.93)	30.3	60.1	63.4	17.5	29.3	58.6
		Soybeans[5]	Wheat[4]	Corn	Oats	Clover	Wheat	Corn	Oats	Clover	Wheat	Corn	Oats	Clover	Corn
201	0..........	10.7	14.5	69.7	46.4	(1.03)	34.4	40.9	67.3	(3.48)	36.1	64.6	49.8	(2.22)	71.7
202	M..........	11.0	14.7	78.8	43.4	(1.40)	40.8	50.9	68.3	(3.71)	34.5	73.8	57.0	(2.99)	83.5
203	ML.........	15.3	12.3	78.2	45.8	(2.54)	49.2	60.0	73.8	(4.36)	26.3	68.3	52.2	(3.21)	89.8
204	MLP.......	13.7	9.7	83.1	45.9	(2.59)	50.0	57.9	53.6	(3.87)	27.3	75.4	49.2	(2.94)	97.8
205	0..........	13.8	13.4	71.6	46.2	1.17	42.5	45.3	72.2	(3.01)	33.1	63.0	53.0	(2.77)	70.9
206	R..........	14.2	13.7	73.9	40.6	.83	49.6	50.4	83.1	(2.84)	29.1	74.5	55.2	(3.59)	94.5
207	RL.........	12.8	9.1	78.8	37.8	.83	49.6	52.9	88.3	(2.84)	26.1	80.2	52.5	(3.09)	76.0
208	RLP........	10.8	14.4	84.5	41.7	.83	53.5	53.3	88.1	(3.20)	32.8	81.1	50.5	(3.44)	96.2
209	RLPK......	11.3	18.2	88.7	44.5	.17	50.4	52.6	92.3	(3.11)	34.8	79.0	56.4	(3.15)	82.7
210	0..........	11.7	15.0	80.5	45.5	(1.24)	39.6	48.7	75.5	(4.59)	36.8	64.5	45.9	(2.74)	68.7

TABLE 5.—ALEDO FIELD, Concluded

Plot No.	Soil treatment applied	1910 Oats[5]	1911 Soybeans[1]	1912 Wheat[3]	1913 Corn	1914 Oats	1915 Soybeans	1916 Wheat	1917 Corn	1918 Oats	1919 Soybeans	1920 Wheat	1921 Corn	1922 Oats	1923 Spring wheat
301	0..........	64.1	15.7	11.5	45.8	42.2	(1.38)	10.2	40.5	74.8	(1.29)	34.8	65.3	65.0	19.4
302	M.........	58.6	17.1	12.6	44.2	51.6	(1.48)	22.2	55.5	76.9	(1.80)	41.5	71.2	68.3	25.0
303	ML......	64.7	15.9	11.7	51.0	52.3	(1.52)	15.8	64.4	83.3	(1.76)	39.7	77.2	72.2	22.6
304	MLP......	57.3	13.6	13.8	49.9	53.1	(1.59)	19.2	68.7	73.4	(1.93)	43.2	74.7	70.3	22.6
305	0..........	68.8	16.9	18.1	43.3	51.2	19.8	12.0	54.9	72.3	12.6	35.2	64.5	53.8	19.2
306	R.........	64.5	15.8	14.4	46.0	51.6	19.8	12.2	53.7	71.4	14.5	29.9	58.6	52.2	19.6
307	RL........	67.2	17.1	10.0	50.1	51.9	22.5	9.2	64.4	78.3	16.2	31.7	74.0	69.8	23.5
308	RLP	55.9	13.3	10.8	48.8	55.2	24.0	12.8	68.6	78.1	17.6	38.5	66.0	68.8	22.8
309	RLPK.....	66.7	13.2	13.3	50.5	52.5	24.8	16.2	70.1	72.3	18.1	38.2	67.0	64.8	22.0
310	0..........	53.6	15.0	9.0	44.8	45.8	(1.44)	13.7	55.6	66 6	(1.37)	37.8	59.7	53.4	17.0

		Corn[5]	Oats[1]	Soybeans[2]	Wheat[3]	Corn	Oats	Clover	Wheat	Corn	Oats	Clover		Wheat	Corn	Oats
												Hay	Seed			
401	0..........	45.9	53.3	(1.41)[6]	39.6	43.7	71.9	(3.26)	21.4	78.8	53.3	(1.84)		40.9	67.4	58.0
402	M.........	74.9	51.7	(1.41)[6]	37.7	57.6	82.0	(3.63)	23.3	85.8	54.2	(2.46)		48.4	84.3	58.4
403	ML........	81.2	53.4	(1.41)[6]	38.0	60.0	89.7	(3.90)	18.6	90.3	49.5	(2.48)		50.8	85.5	77.2
404	MLP......	82 1	51.6	(1 41)[6]	37.7	62.9	93.4	(3.86)	19.4	89.4	51.9	(2.68)		50.5	82.6	83.8
405	0..........	80.9	39.7	16.4	38.2	38.7	73.4	.25	28.2	81.8	49.7	(1.57)	2.75	41.7	71.7	56.3
406	R.........	67.7	60.3	15.2	42.3	47.9	74.5	.33	26.9	85.2	51.4	(1.58)	1.71	43.8	74.7	67.7
407	RL........	67.4	62.8	14 6	38.8	48.3	83.6	.25	28.0	97.1	52 3	(1.51)	.96	45.0	77.7	69.4
408	RLP.......	71.7	62.5	16.4	40.0	48.4	81.2	.25	28.2	96.7	50.9	(1.48)	1.50	50.6	79.0	74.1
409	RLPK.....	77.8	55.5	15.8	38.9	52.7	93.8	.18	22.7	98.3	53.0	(1.28)	1.17	42.2	78.5	74.5
410	0..........	67.1	52.3	14.5	34.7	40.7	58.3	(2.30)	20.8	72.8	47.3	(1.50)		40.7	62.5	74.1

[1]Residues only. [2]No manure, phosphate, or potassium. [3]No manure. [4]No manure or lime. [5]No treatment. [6]Estimated.

TABLE 6.—ALEDO FIELD: GENERAL SUMMARY OF THE GRAIN CROPS
Average Annual Yields 1912-1922—Bushels per acre

Serial Plot No.	Soil treatment applied	Wheat *8 crops*	Corn *11 crops*	Oats *10 crops*
1	0	29 9	57.3	59.0
2	M	34.0	68.7	63.8
3	ML	33.4	70.8	65.0
4	MLP	35.5	72.2	64.7
5	0	31.2	59.4	61.2
6	R	31.5	63.2	60.4
7	RL	32.4	69.5	64.5
8	RLP	36.9	70.4	65.2
9	RLPK	35.0	70.8	67.2
10	0	31.1	58.7	56.0
	M over 0	3.3	10.2	5.1
	R over 0	.8	.9	2.5
	ML over M	−.6	2.1	1.2
	RL over R	.9	6.3	4.1
	MLP over ML	2.1	1.4	−.3
	RLP over RL	4.5	.9	−.7
	RLPK over RLP	−1.9	.4	2.0

average yields, the increase becoming particularly marked in the corn crop in the residues system.

Aside from the case of the wheat, the results show little or no effect from adding rock phosphate to the treatment, and at prevailing prices the cost of applying the phosphate would not be covered. However, the economic story has not all been told, for the application of lime and phosphate on these plots is to be discontinued in order to observe the residual effects. The results of the next few years, therefore, will be awaited with great interest.

For the effect of potassium treatment, we may compare Plots 8 and 9. No significant response appears as the result of applying potassium, so far as these common field crops show.

Future Experiments on the Major Series

A number of problems have arisen out of the experience on this and other experiment fields which call for some revision of the investigations described above, and accordingly certain changes are to be made in the future conduct of these plots to which attention may be called at this point.

It seems evident from the results presented above that limestone is not needed on this field to the extent to which it has been applied. Limestone, therefore, is to be temporarily discontinued on some plots until its need shall be made manifest by the behavior of sweet clover or thru other tests.

Another problem needing investigation is the economic use of rock phosphate. This material has been applied on these plots liberally, so that a considerable reserve of phosphorus should have accumulated. In order to observe the residual effect of rock phosphate, the application of this material will likewise be discontinued after bringing the total quantity applied up to 4 tons per acre. At the same time, a comparison of rock phosphate with acid phosphate and with bone meal will be made.

In order to provide for these new experiments, the plots of the major series will be divided in the middle into east and west halves. Aside from a change in the crop rotation affecting all plots in these series, the west half of each plot will receive essentially the same treatment and management as in in past, and the new experiments will be mainly on the east halves.

Inasmuch as it is the present purpose merely to mention these changes without going into a discussion of details, the following tabular statement will suffice to outline the plan of the future experiments on these plots.

TREATMENT TO BE APPLIED ON SERIES 100, 200, 300 AND 400: ALEDO FIELD

Plot	West Half	East Half
1	None	Legume, residues, limestone[1]
2	Manure	Manure, rock phosphate
3	Manure, limestone[2]	Manure, limestone[2], bone meal
4	Manure, limestone[2], rock phosphate[3]	Manure, limestone[2], rock phosphate
5	None	Legumes, residues, acid phosphate
6	Legumes, residues	Legumes, residues, rock phosphate
7	Legumes, residues, limestone[2]	Legumes, residues, limestone[2], acid phosphate
8	Legumes, residues, limestone[2], rock phosphate	Legumes, residues, limestone[2], rock phosphate
9	Legumes, residues, limestone[2], rock phosphate[3], potassium	Legumes, residues, limestone[2], rock phosphate[3], potassium, gypsum
10	None	Legumes, residues, limestone[1], rock phosphate

[1] Limestone to be applied as needed.
[2] Limestone applications discontinued until needed.
[3] Rock phosphate applications discontinued.

In 1923 a modification of the cropping system was put into effect, the rotation being changed to corn, corn, oats, and wheat. The plan includes also a catch crop of annual sweet clover seeded with the oats on all plots and biennial sweet clover grown as green manure in the wheat on both halves of Plots 6, 7, 8, and 9 and on the east half of Plots 1, 5, and 10.

Experiments on the Minor Series

The so-called minor system of plots (Series 500, 600, 700, 800) on the Aledo field is given over to a comparison of the effectiveness of different carriers of phosphorus. The plots for this work were laid out in 1916. This land had been previously in alfalfa since 1911. Excellent crops of alfalfa were harvested, in one of the years nearly 7 tons per acre being recorded as the season's yield.

The crops planted each year on these plots are alike on all series and they have been grown as indicated in Table 7. It is planned that hereafter the crop of any year will correspond to that growing on the 200 series of the major system.

In this experiment each series contains four plots. Plot 1 receives residues treatment only; Plot 2 receives residues and phosphorus in one of the forms under test; Plot 3 receives residues, limestone, and phosphorus; and Plot 4 is similar to Plot 3 with phosphorus omitted. On the 500 series, steamed bone meal (bP) is used as the carrier of phosphorus and is applied at the rate of 200 pounds per acre per year. On the 600 series, acid phosphate (aP) is applied at the yearly rate of 333⅓ pounds per acre. On the 700 series, rock phosphate (rP) serves as the source of phosphorus, applied at the rate of 666⅔ pounds per acre yearly. On the 800 series, basic slag phosphate (sP) is applied at the rate of 250 pounds per acre yearly.

TABLE 7.—ALEDO FIELD: PHOSPHATE EXPERIMENT
Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied[1]	1916[2] Corn	1917[2] Oats	1918[2] Soybeans	1919 Wheat	1920 Corn	1921 Oats	1922 Clover hay	1923 Corn	1924 Corn
501	R	53.4	85.5	18.9	32.4	72.8	48.9	(2.88)	83.5	58.2
502	RbP	61.7	91.7	19.0	34.7	86 4	61.9	(3.25)	82.7	66.0
503	RLbP	61.5	90.6	23.2	35.6	87.3	53.3	(3.48)	82.5	66.8
504	RL	55.1	80.5	22.6	32.9	77.7	47.7	(2.61)	88.2	60.3
601	R	55.2	84.7	19.5	33.0	71.2	53.6	(3.17)	84.7	57.3
602	RaP	57.8	87.7	18.7	38.3	87.1	60.9	(3.23)	82.5	65.9
603	RLaP	64.7	83.4	23.1	38.2	88.1	52.3	(3.53)	77.6	64.7
604	RL	51.9	81.7	24.6	32.8	84.9	50.2	(3.06)	84.1	51.9
701	R	54.3	83.1	20.8	34.2	75.6	52.8	(3.41)	82.8	61.2
702	RrP	58.8	83.3	23.3	36.7	80.4	63.0	(3.60)	87.8	69.3
703	RLrP	57.2	81.2	28.1	36.7	80.2	53.3	(3.82)	86.6	70.8
704	RL	52.1	81.7	26.9	34.1	82.0	48.9	(3.15)	84.6	62.5
801	R	57.6	73.8	18.0	33.7	68.1	54.8	(2.62)	74.3	58.8
802	RsP	56.4	87.8	20.6	38.1	81.0	66.2	(3.66)	80.0	69.1
803	RLsP	53.3	78.9	23.7	38.4	83.6	57.0	(3.63)	82.0	70.2
804	RL	51.8	77.5	21.8	33.3	70.4	59.8	(2.99)	82.6	59.9

[1]Bone meal (bP) at the rate of 200 pounds per acre per year.
Acid phosphate (aP) at the rate of 333⅓ pounds per acre per year.
Rock Phosphate (rP) at the rate of 666⅔ pounds per acre per year.
Slag phosphate (sP) at the rate of 250 pounds per acre per year.
All minerals applied once in the rotation ahead of the wheat crop.
[2]No residues.

The yields for all crops harvested on these plots during the first nine years are recorded in Table 7. Table 8, which is derived from Table 7, shows differences in crop yields presumed to have resulted from applying the various forms of phosphatic fertilizers for the nine crops harvested since the beginning of the applications up to 1924. In computing these comparisons all residues plots are combined into a single average for the respective crops, as are all lime-residues plots, and these figures stand as checks against those for the corresponding phosphated plots.

Aside from the soybeans, the figures show without exception more or less crop increase on the phosphorus plots, no matter what the form of carrier em-

TABLE 8.—ALEDO FIELD: CROP INCREASES FOR VARIOUS FORMS OF PHOSPHATE BASED UPON RESULTS IN TABLE 7
1916-1924

Comparison of treatments	Wheat *1 crop*	Corn *4 crops*	Oats *2 crops*	Clover *1 crop*	Soybeans *1 crop*
Bone meal and residues over residues	1.4	7.4	9.7	(.23)	−.3
Bone meal, lime, and residues over lime and residues	2.3	5.8	5.9	(.53)	−.8
Acid phosphate and residues over residues	5.0	6.5	7.2	(.21)	−.6
Acid phosphate, lime and residues over lime and residues	4.9	5.0	1.8	(.58)	−.9
Rock phosphate and residues over residues	3.4	7.3	6.0	(.58)	4.0
Rock phosphate, lime and residues over lime and residues	3.4	4.9	1.2	(87)	4.1
Slag phosphate and residues over residues	4.8	4.8	9.9	(.64)	1.3
Slag phosphate, lime, and residues over lime and residues	5.1	3.5	1.4	(.68)	−.3

ployed. The difficulty, however, of arriving at a general conclusion regarding the comparative economy in the use of these different phosphorus materials is obvious, for all depends upon their relative cost, which fluctuates from time to time. Furthermore, the prices received from farm produce likewise fluctuate; and to complicate matters still further, these fluctuations do not necessarily run parallel with those of the fertilizer cost. However, one may readily compute for himself the relative economy of producing these crop increases by applying any set of prices for crops and fertilizers which appear to be most applicable according to prevailing market conditions.

For the purpose of furnishing an illustration of such a computation, the following set of arbitrary prices may be assumed as representing approximately average market conditions for the past ten years: wheat, $1.25 per bushel; corn, 75 cents; oats, 45 cents; soybeans, $1.50; and clover, $15 per ton. For the cost of the various phosphatic materials the following estimates are used: bone meal, $40 per ton; acid phosphate, $24; rock phosphate, $12; and slag phosphate, $20. These values seem to be conservative enough. The figures for crop values are all under the average December 1 farm price quotations for the ten-year period 1914-1923. Furthermore, it may be pointed out that the quantities of phosphatic materials employed in these experiments are, with the possible exception of the slag phosphate, greater than ordinarily would be used, or need to be used, in good farm practice.

Figured on the basis of these prices, it appears that both bone meal and acid phosphate, as used on these plots, have been applied at a financial loss, whether accompanied by limestone or not, while rock phosphate and slag phosphate have each yielded a profit. Counting in all crops, the net loss for bone meal was 4 cents per acre per year when applied without limestone, and 41 cents applied with limestone. The use of acid phosphate without limestone resulted in a loss of 17 cents, while with limestone the loss was 66 cents. Rock phosphate produced a profit of $1.14 when used without limestone, but with limestone the profit was reduced to 36 cents. Slag phosphate furnished the most profitable return of any of the phosphorus carriers, producing an average profit of $2.04 an acre yearly when used without limestone and 60 cents used with limestone.

In considering these figures let it be emphasized again that the order of these values might easily be shifted by a relatively small change in commodity prices.

Considering the results from the standpoint of limestone as applied on the plots of the minor series, the following observations are to be made.

Limestone at the rate of 4 tons per acre was applied to Plots 3 and 4 in 1912, when the land was still under alfalfa, and another dressing was added in 1917, after the present experiments were under way. The effect of this limestone, in terms of crop increase, is set forth in Table 9.

Comparing, first, the results from the check plots, which receive no phosphorus, it appears that the limestone used with residues alone has been of benefit to the corn and the soybean crops only.

Considering all treatments as a whole, the soybeans exhibit a consistent gain in yield from the use of limestone, while oats, on the other hand, respond by a consistent loss. Wheat and corn on the whole show a rather indifferent response. If we consider the money value of these crop increases on the same basis as above,

TABLE 9.—ALEDO FIELD: CROP INCREASES FOR LIMESTONE
BASED UPON RESULTS IN TABLE 7
1916-1924

Comparison of treatments	Wheat *1 crop*	Corn *4 crops*	Oats *2 crops*	Clover *1 crop*	Soybeans *1 crop*
Residues, limestone over residues	.0	2.0	−1.2	(−.07)	4.7
Residues, limestone, bone meal over residues, bone meal	.9	.3	−4.8	(.23)	4.2
Residues, limestone, acid phosphate over residues, acid phosphate	−.1	.5	−6.4	(.30)	4.4
Residues, limestone, rock phosphate over residues, rock phosphate	.0	−.4	−5.9	(.22)	4.8
Residues, limestone, slag phosphate over residues, slag phosphate	.3	.7	−9.0	(.33)	3.1

we find a gross return for limestone, applied without phosphate, of $1.30 per acre per year. Limestone with bone meal has returned, in gross, 83 cents per acre per year; with acid phosphate, 73 cents; with rock phosphate, 44 cents; and with slag phosphate, 65 cents. It is doubtful, therefore, whether limestone, used with phosphates in the manner described has, up to the present time, paid its cost on these plots. The Aledo field represents one of these borderline cases, so to speak, in which the upper soil is neutral or only slightly acid and the lime requirement, therefore, not yet very marked. As time goes on, however, and cropping continues, the need of lime will develop. It is planned to discontinue liming on these plots until its need becomes manifest, and in so doing the annual cost of the limestone already applied will become automatically reduced, so that net returns which hitherto have represented a loss may sooner or later result in a positive profit.

The Galesburg Field

Another field which should be of especial interest in this Report, because it was located only a few miles from Mercer county, is the Galesburg field on Brown Silt Loam. This field lay six miles west of Galesburg. It was established in 1904 and was continued until 1918. It was laid out into three series of twenty plots each with treatments as indicated in Table 10. The original rotation was corn, corn, oats, wheat, clover, and timothy, but this was changed in 1909 to corn, corn, oats, clover, wheat, and clover.

All phosphorus was applied in the form of rock phosphate at the rate of 500 pounds per acre per year. At the beginning, a dressing of 1,300 pounds of limestone per acre was applied and no more was applied until 1913, when an application of 4 tons per acre was made. The potassium was applied in 100 pounds of potassium sulfate per acre. On Plot 19 nitrogen was applied in 200 pounds of dried blood per acre yearly. Some legume cover crops were grown in the corn.

A general summary of the annual crop yields is assembled in Table 10. For the sake of convenience in studying the effect of the treatments, the various possible comparisons are brought together in Table 11, where the results are ex-

pressed in terms of crop increases. Following are some of the salient points brought out by these comparisons.

1. Residues without limestone produced very little effect on crop yields, but used with limestone there was a noticeable increase in the residues plots over the non-residues plots.

2. Manure used in the liberal manner of these experiments, along with limestone, produced very beneficial effects. Measured by crop increases, the effect of manure and limestone was about twice that of residues and limestone. It should be borne in mind, however, in this connection that in this system the land received regularly about 3 tons of manure per acre yearly, a practice that would be difficult to carry out on many farms.

3. The use of limestone alone, all crops considered, resulted in a financial loss. In combination with residues, however, limestone produced a beneficial effect.

4. Rock phosphate in the residues system produced very pronounced and profitable increases in crop yields, used either with or without limestone. Also, without residues the increases in crop yields were large.

Used with animal manure, however, the increases resulting from phosphate were not nearly so large; in fact, the increases attributable to phosphorus in the manure system are scarcely sufficient to cover the cost of the rock phosphate employed. This is a commonly observed result, explained probably by the fact that

TABLE 10.—GALESBURG FIELD: GENERAL SUMMARY OF CROP YIELDS
Average Annual Yields 1908-1918—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn following clover *6 crops*	Corn following corn *5 crops*	Corn average *11 crops*	Oats *5 crops*	Wheat *4 crops*	Barley *1 crop*	Clover *4 crops*	Soybeans *4 crops*
1	L.........	54.8	45.9	50.8	44.4	21.7	22.5	(2.12)	(1.16)
2	RL........	65.6	53.1	59.9	47.5	26.6	27.1	....	13.8
3	ML........	73.8	61.1	68.0	47.8	28.9	25.5	(2.67)	(1.56)
4	CvML.....	75.1	60.8	68.6	47.4	28.4	25.6	(2.45)	(1.53)
5	L.........	61.6	51.0	56.7	46.8	25.2	21.7	(2.37)	(1.27)
6	LP........	70.6	58.1	64.9	51.1	33.8	24.2	(2.86)	14.1
7	RLP......	74.9	58.0	67.2	51.8	36.4	29.8	....	15.6
8	MLP......	76.1	65.1	71.1	51.0	32.7	26.8	(2.90)	(1.65)
9	CvMLP ...	74.7	66.1	70.8	50.8	33.3	33.0	(2.91)	(1.62)
10	L.........	59.7	47.3	54.1	45.9	22.2	23.0	(1.94)[1]	12.7
11	LPK......	68.8	60.9	65.2	49.4	32.7	22.7	(3.03)	15.5
12	RLPK.....	75.1	61.7	69.0	48.2	34.8	38.4	....	15.9
13	MLPK.....	73.8	63.8	69.3	49.8	32.3	29.7	(3.11)	(1.75)
14	CvMLPK..	74.8	67.0	71.3	48.0	33.3	35.1	(3.27)	(1.67)
15	L.........	60.7	46.1	54.0	43.4	19.6	25.5	(2.08)	(1.31)
16	R.........	62.8	49.7	56.8	43.7	24.7	33.3	....	12.5
17	RP........	71.1	54.2	63.4	51.9	36.0	31.5	....	14.2
18	RPK......	74.3	56.4	66.2	51.9	39.2	32.6	....	14.3
19	RLNPK...	79.1	60.4	70.6	52.4	36.5	39.1	....	17.4
20	0...........	59.3	47.6	54.0	43.3	25.8	24.9	(1.82)	(1.14)

[1]Only 2 crops from this plot.

the manure itself carries a considerable quantity of phosphorus which supplies directly much of the crops' need for this element of plant food.

5. Potassium in the form of potassium sulfate appears in five different fertilizer combinations on these plots, but the various possible comparisons show no significant effect from potassium. In a large proportion of the cases the figures indicating increase carry the minus sign, and altogether the small differences exhibited are doubtless well within experimental error.

6. Nitrogen, as applied in the form of dried blood and in combination with residues, limestone, phosphorus, and potassium, likewise proved ineffective, resulting in a considerable economic loss thru cost of material.

7. Cover crops, in the three different combinations tried, produced no significant effect so far as crop yields indicate.

TABLE 11.—GALESBURG FIELD: EFFECT OF TREATMENTS IN TERMS OF ANNUAL CROP INCREASES

Bushels or (tons) per acre

Comparison of treatments	Corn *11 crops*	Oats *5 crops*	Wheat *4 crops*	Barley *1 crop*	Clover *4 crops*	Soybeans *4 crops*
Residues						
R over 0	2.8	.4	−1.1	8.4	....	....
RL " L	6.0	2.4	4.4	3.9	....	1.1
RLP " LP	2.3	.7	2.6	5.6	....	1.5
RLPK " LPK	3.8	−1.2	2.1	15.7	....	.4
Manure						
ML over L	14.1	2.7	6.7	2.3	(.54)	(.31)
MLP " LP	6.7	− .1	6.1	2.6	(.04)	....
MLPK " LPK	4.1	.4	− .4	7.0	(.08)	....
Limestone						
L over 0	− .1	1.8	−2.6	−1.7	(.31)	(.11)
LR " R	3.1	3.8	1.9	−6.2	....	1.3
LRP " RP	3.8	− .1	.4	−1.7	....	1.4
LRPK " RPK	2.8	−2.7	−4.4	5.8	....	1.6
Phosphorus						
PR over R	6.6	8.2	11.3	−1.8	....	1.7
PL " L	11.0	6.0	11.6	1.0	(.73)	1.4
PRL " RL	7.3	4.3	9.8	2.7	....	1.8
PML " ML	3.1	3.2	3.8	1.3	(.23)	(.09)
PMLCv " MLCv	2.2	3.4	4.9	7.2	(.46)	(.09)
Potassium						
KRP over RP	2.8	0.0	3.2	1.1	....	.1
KLP " LP	.3	−1.7	−1.1	−1.5	(.17)	1.4
KRLP " RLP	1.8	−3.6	−1.6	8.6	....	.3
KMLP " MLP	−1.8	−1.2	− .4	2.9	(.21)	(.10)
KMLPCv " MLPCv	.5	−2.8	0.0	2.1	(.36)	(.05)
Commercial nitrogen						
NRLPK over RLPK	1.6	4.2	1.7	.7	....	1.5
Cover Crops						
CvML over ML	.6	− .4	− .5	.1	(−.22)	(−.03)
CvMLP " MLP	− .3	− .2	.6	6.2	(−.01)	(−.03)
CvMLPK " MLPK	2.0	−1.8	1.0	5.4	(.16)	(−.08)

TABLE 12.—KEWANEE FIELD: GENERAL SUMMARY OF THE GRAIN CROPS
Average Annual Yields 1917-1924—Bushels per acre

Serial Plot No.	Soil treatment applied	Wheat *6 crops*	Corn *8 crops*	Oats *8 crops*
1	0	31.0	54.1	58.8
2	M	32.7	63.5	68.1
3	ML	35.6	67.6	71.3
4	MLP	38.8	67.6	70.1
5	0	32.2	55.1	60.9
6	R	32.9	56.9	58.7
7	RL	33.1	65.7	63.0
8	RLP	38.1	68.8	65.9
9	RLPK	38.2	71.7	67.5
10	0	30.6	50.6	55.3
	M over 0	1.4	10.2	9.8
	R " 0	1.6	3.6	.4
	ML " M	2.9	4.1	3.2
	RL " R	.2	8.8	4.3
	MLP " ML	3.2	0.0	−1.2
	RLP " RL	5.1	3.1	2.9
	RLPK " RLP	.1	2.9	1.6

The Kewanee Field

Another field in the vicinity of Mercer county representing Brown Silt Loam is the Kewanee field, located in Henry county about three miles southwest of Kewanee. This field has been under way since 1915. The crops grown are wheat, corn, oats, and clover. The arrangement of plots and the treatments applied are indicated in Table 12. This table includes the yields of the grain crops only.

Summarizing the data as in Table 12 the following observations may be made.

1. The response to treatment with stable manure stands out clearly in the increased production.

2. Residues without limestone have not produced a very decided effect on crop yields.

3. The effect of limestone appears to have been beneficial used either with manure or with residues.

4. Phosphorus, as usual, has been more effective applied with residues than with manure. In the residues system the rock phosphate has been applied with profit, while in the manure system the increases in crop yield are not sufficient to cover the cost.

5. Potassium has produced no effect upon the yields of these crops that can be considered significant.

EXPERIMENTS ON BLACK CLAY LOAM

The Hartsburg Field

The results of experiments on the Hartsburg field are introduced as representing the soil type Black Clay Loam. This field is located in Logan county just east of Hartsburg. The work began in 1913. The field was laid off into

TABLE 13.—HARTSBURG FIELD: GENERAL SUMMARY OF THE GRAIN CROPS
Average Annual Yields 1913-1924—Bushels per acre

Serial Plot No.	Soil treatment applied	Wheat *9 crops*	Corn *12 crops*	Oats *11 crops*
1	0	23.9	44.0	46.6
2	M	29.3	52.6	51.8
3	ML	36.1	59.5	57.8
4	MLP	39.0	58.5	57.7
5	0	31.8	48.3	44.7
6	R	34.3	59.3	54.6
7	RL	32.8	64.0	52.5
8	RLP	36.5	61.9	56.8
9	RLPK	35.4	61.7	56.2
10	0	32.3	49.0	47.9
	M over 0	0.0	5.5	4.4
	R " 0	5.0	12.2	7.2
	ML " M	6.8	6.9	6.0
	RL " R	−1.5	−2.1	4.7
	MLP " ML	2.9	−1.0	− .1
	RLP " RL	3.7	−2.1	4.3
	RLPK " RLP	− .9	− .2	− .6

five series of 10 plots each. The crop rotation up to 1923 was wheat, corn, oats, and clover, with alfalfa growing on a fifth series. The soil treatments are as indicated in Table 13. The table summarizes the yields, by crops, for the period during which the plots have been under full treatment.

The outstanding feature of these results is the large increase in yields produced by residues, which even exceeds the increase brought about by the use of stable manure.

The behavior of limestone on this field is rather peculiar in that it has been more beneficial where applied with manure than where used with residues. Used with manure, limestone gave a substantial increase in all grain crops, while with residues, the effect on both wheat and corn appears negative.

Altho rock phosphate has given some increases in wheat yield in both manure and residues systems, the results with other crops have been such as to render the use of this material unprofitable on this field.

The addition of potassium appears to have produced a slightly depressing effect upon the yields of all grain crops.

It may be mentioned that new experiments have been recently started on these plots which are designed to answer some of the questions brought out by the foregoing results. For example, the effect of applying phosphorus in other carriers and in different combinations, as well as testing the residual effect of phosphate already applied, will be tried.

EXPERIMENTS ON YELLOW SILT LOAM

Inasmuch as about one-fifth of the area of Mercer county is made up of Yellow Silt Loam, much of which is subject to erosion, it is believed that an account of some experiments on the Vienna field will be of interest here.

The Vienna Field

In 1906 the University acquired a sixteen-acre tract of land near Vienna in Johnson county. The whole area with the exception of about three acres had been abandoned because so much of the surface soil had washed away and there were so many gullies as to render further cultivation of this land unprofitable. Experiments were started at once to reclaim this land, the different methods described below being used for this purpose.

The field was divided into five sections. The sections designated as A, B, and C were divided into four plots each, and D into three plots. On section A, which included the steepest part of the area and contained many gullies, the land was built up into terraces at vertical intervals of five feet. Near the edge of each terrace a small ditch was placed so that the water could be carried to a natural outlet without doing much washing.

On section B the so-called embankment method was used. By this method erosion is prevented by plowing up ridges so that water will run over in a broad sheet rather than in narrow channels. At the steepest part of the slope, hillside ditches were made for carrying away the run-off.

Section C was washed badly but contained only small gullies. Here the attempt was made to prevent washing by incorporating organic matter in the soil and practicing deep contour plowing and contour planting. With two exceptions, about eight loads of manure per acre were turned under each year for the corn crop.

The land on section D was washed to about the same extent as that of section C. As a check on the different methods of reducing erosion, the land on section D was farmed in the most convenient way, without any special effort being made to prevent washing.

Section E was badly eroded and gullied and no attempt was made to crop it other than to fill in the gullies with brush and to seed the land to grass.

Sections A, B, C, and D were not entirely uniform; some parts were washed more than others and portions of the lower-lying land had been affected by soil material washed down from above. When the field was secured, the higher land had a very low producing capacity. On many spots little or nothing would grow.

Limestone was applied to the entire field at the rate of 2 tons per acre. Corn, cowpeas, wheat, and clover were grown in a four-year rotation on each section except D which had but three plots.

Table 14 contains a summarized statement of the results obtained.

TABLE 14.—VIENNA FIELD: HANDLING HILLSIDE LAND TO PREVENT EROSION
Average Annual Yields, 1907-1915—Bushels or (tons) per acre

Section	Method	Corn *7 crops*	Wheat *7 crops*	Clover *3 crops*
A	Terrace	31.4	9.0	(0.68)
B	Embankments and hillside ditches	32.4	12.7	(0.97)
C	Organic matter, deep contour plowing, and contour planting	27.9	11.7	(0.80)
D	Check	14.1	4.6	(0.21)

FIG. 4.—VIEW OF AN UNIMPROVED HILLSIDE JUST OVER THE FENCE FROM THE FIELD SHOWN IN FIG. 5

These results indicate something of the possibilities in improving hillside land by protecting it from erosion. The average yield of corn from the protected series (A, B, and C) was 30.6 bushels per acre, as against 14.1 bushels for series D; wheat yielded 11.1 bushels in comparison with 4.6 bushels; and clover .82 ton in comparison with .21 ton.

A comparison of Figs. 5 and 6 will serve to indicate the possibility of improving this type of soil.

EXPERIMENTS ON DUNE SAND

In 1913 the University came into possession of a tract of Dune Sand, Terrace, in Henderson county, near the Mississippi river, upon which an experi-

FIG. 5.—CORN GROWING ON IMPROVED HILLSIDE OF THE VIENNA EXPERIMENT FIELD. THIS LAND FORMERLY HAD BEEN BADLY ERODED. COMPARE WITH FIG. 4

ment field was laid out to determine the needs of these sand soils. This field is divided into six series of plots. Corn, soybeans, wheat, sweet clover, and rye, with a catch crop of sweet clover seeded in the rye on the residues plots, are grown in rotation on five series, while the sixth series is devoted to alfalfa. When sweet clover seeded in the wheat fails, cowpeas are substituted.

No catch of alfalfa or of sweet clover was obtained till the alfalfa drill was used in seeding. With this implement the seed is covered about one-half inch deep.

Table 15 indicates the kinds of treatment applied, the amounts of the materials used being in accord with the standard practice, as explained on page 41.

The data make apparent the remarkably beneficial action of limestone on this sand soil. Where limestone has been used in conjunction with crop residues, the yield of corn has been doubled. The limestone has also produced good crops of rye and fair crops of sweet clover and alfalfa.

This land appears to be quite indifferent to treatment with rock phosphate. The analyses show, however, that the stock of phosphorus in this type of soil is not large, and it may develop as time goes on and the supply diminishes along with the production of good-sized crops, that the application of this element will become profitable. It is also quite possible that a more available form of phosphate could be used to advantage on this very sandy soil.

Altho the results show an increase of 3.5 bushels of corn from the use of potassium salts, with ordinary prices this would not be a profitable treatment. The slight increase from the use of potassium appearing in the other crops can scarcely be considered significant.

A significant fact which the general summary does not bring out is that the improvement under favorable treatment has been progressive, as evidenced by a very marked upward trend in production after the first few years. For example, we note that the yield of corn under the limestone-residues treatment has

TABLE 15.—OQUAWKA FIELD: GENERAL SUMMARY OF CROP YIELDS
Average Annual Yields 1915-1923—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *9 crops*	Soybeans *8 crops*		Wheat *9 crops*	Sweet clover[1] *7 crops*		Rye *7 crops*	Alfalfa *6 crops*
			Hay *5 crops*	Seed *3 crops*		Hay *4 crops*	Seed *3 crops*		
1	0..........	17.8	(.89)	8.1	7.3	(.00)	.00	11.7	(.32)
2	M..........	22.1	(1.01)	9.7	10.0	(.00)	.00	12.8	(.52)
3	ML........	27.8	(1.27)	12.8	13.4	(1.20)	1.06	22.7	(1.98)
4	MLP......	26.2	(1.20)	13.0	13.7	(1.26)	.99	21.6	(2.12)
				Seed *8 crops*		Hay *2 crops*	Seed *5 crops*		
5	0..........	17.4	....	5.6	9.5	(.00)	.00	11.8	(.07)
6	R..........	20.4	....	5.7	10.3	(.00)	.00	12.9	(.06)
7	RL........	34.6	....	8.8	13.0	(1.47)	1.61	23.9	(1.79)
8	RLP......	34.0	....	8.9	13.6	(1.39)	1.45	24.5	(1.71)
9	RLPK.....	37.5	....	8.3	12.4	(1.53)	1.72	25.3	(1.86)
10	0..........	17.0	(.60)	6.1	7.9	(.00)	.00	11.0	(.03)

[1]In 1918 sweet clover was killed by being cut for hay. Soybeans were seeded on these plots and the following yields obtained: .86, 1.10, 1.93, and 2.00 tons of hay per acre on Plots 1 to 4; 11.1, 9.9, 14.6, 15.8, and 16.6 bushels of seed per acre on Plots 5 to 9; and .62 ton of hay per acre on Plot 10.

Manure
Yield: Nothing

Manure and limestone
Yield: 4.43 tons per acre

FIG. 6.—ALFALFA ON OQUAWKA FIELD IN 1918

been 34.6 bushels per acre as an average for the 9 crops since full treatment started, but if we take an average of the last five crops the yield rises to 42.7 bushels. Likewise the wheat under this same treatment gives for the 9-year average 13 bushels, but the last five years has given 16.9 bushels.

Experience thus far shows rye to be better adapted to this land than wheat, and both alfalfa and sweet clover thrive better than soybeans. With these two legume crops thriving so well under this simple treatment, we have promise of great possibilities for the profitable culture of this land, which hitherto has been considered as practically worthless.

Soil Reports Published

1 Clay, 1911
2 Moultrie, 1911
3 Hardin, 1912
4 Sangamon, 1912
5 LaSalle, 1913
6 Knox, 1913
7 McDonough, 1913
8 Bond, 1913
9 Lake, 1915
10 McLean, 1915
11 Pike, 1915
12 Winnebago, 1916
13 Kankakee, 1916
14 Tazewell, 1916
15 Edgar, 1917
16 DuPage, 1917
17 Kane, 1917
18 Champaign, 1918
19 Peoria, 1921
20 Bureau, 1921
21 McHenry, 1921
22 Iroquois, 1922
23 DeKalb, 1922
24 Adams, 1922
25 Livingston, 1923
26 Grundy, 1924
27 Hancock, 1924
28 Mason, 1924
29 Mercer, 1925

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 30

JOHNSON COUNTY SOILS

By R. S. SMITH, E. A. NORTON, E. E. DeTURK, F. C. BAUER, and L. H. SMITH

URBANA, ILLINOIS, JUNE, 1925

The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died, and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or landowner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and landowner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due the late Professor J. G. Mosier, under whose direction the soil survey of Johnson county was conducted, and to Mr. H. C. Wheeler, who was in direct charge of the field party in the construction of the map.

CONTENTS OF SOIL REPORT No. 30
JOHNSON COUNTY SOILS

APPENDIX

SUPPLEMENT

JOHNSON COUNTY SOILS

By R. S. SMITH, E. A. NORTON, E. E. DeTURK, F. C. BAUER and L. H. SMITH[1]

LOCATION AND CLIMATE OF JOHNSON COUNTY

Johnson county is located in the southern part of Illinois, midway between the Ohio and Mississippi rivers and about 30 miles north of their junction. The county is practically square, embracing an area of 336 square miles.

The climate of Johnson county is characterized by a wide range between the extremes of winter and summer. According to the records of the Weather Bureau Station at New Burnside, the greatest range of temperature in any year from 1895 to 1924 was 129 degrees in 1918. The lowest temperature recorded was –26° in 1912; the highest, 112° in 1901. The average date of the last killing frost in spring is April 17; the earliest in fall, October 22. The length of the growing season therefore is about 188 days.

The average annual precipitation for the county, from 1895 to 1924, was 43.73 inches. The highest rainfall in any one year, that in 1923, was 57.64 inches; the lowest, in 1901 was 28.08 inches. The average annual rainfall by months for this period was as follows: January, 3.97 inches; February, 2.76; March, 4.39; April, 4.45; May, 4.03; June, 3.47; July, 3.68; August, 3.47; September, 3.18; October, 3.07; November, 3.22; December, 3.65. The proportion of total rainfall occurring during each season was: winter, 23.9 percent; spring, 29.7 percent; summer, 24.5 percent; autumn, 21.9 percent.

AGRICULTURAL PRODUCTION

Altho Johnson county is distinctly agricultural, for it has no other industries of importance, only 22 percent of the total acreage was devoted to the growing of grain crops and hay in 1919, as reported by the Census of 1920. This same Census reports that there were 1,742 farms in the county, having an average acreage of 110.8 acres each. This is a slight decrease in the number of farms during the previous decade. Observation indicates that there has been a more rapid decrease in the number of farms since 1919, and that at the present time the number probably does not greatly exceed 1,000.

The principal field crops are corn, wheat, oats, pasture, and hay. Within very recent years, cotton has received considerable attention in this county. The climate of this region is not particularly well suited to cotton production because of danger of frost injury before the crop is mature. The bottom lands, when well drained, are adapted to the growth of this crop, and the comparatively level land adjacent to the bottoms may also be used to good advantage for cotton. Tobacco is grown to some extent and appears to have a more promising future in the county than does cotton. There were about 250 acres grown in 1923 and a consistent increase in acreage is to be expected if prices do not fall below the level of profitable production.

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[1]R. S. Smith, in charge of soil survey mapping; E. A. Norton, first assistant in soil survey mapping; E. E. DeTurk, in charge of soil analysis; F. C. Bauer, in charge of experiment fields; L. H. Smith, in charge of publications.

The Census reports the following as the acreage and yield of some of the more important crops for the year 1919:

Crops	*Acreage*	*Production*	*Yield per acre*
Corn	28,746	545,155 bu.	18.9 bu.
Oats	2,219	33,641 bu.	15.1 bu.
Wheat	7,097	76,856 bu.	10.8 bu.
Timothy	8,680	10,015 tons	1.1 tons
Timothy and clover mixed	5,354	6,202 tons	1.1 tons
Clover (alone)	830	1,063 tons	1.3 tons
Silage crops	842	3,197 tons	3.8 tons
Corn for forage	1,542	1,801 tons	1.1 tons

The total value of all crops in 1919 was $2,210,447.

The soil and topography are the primary factors which make Johnson county a fruit-growing center. This industry is becoming more important each year. The 1920 Census reports the following production of fruit: apples, 126,134 bushels; peaches, 12,689; pears, 5,220; cherries, 890; grapes, 26,268 pounds; and small fruits, including strawberries, raspberries, blackberries, and dewberries, 68,825 quarts. The production of vegetables is receiving increased attention and should become an important industry in the county.

The livestock interests, particularly those of the dairy, are of considerable importance, as shown by the following data, also taken from the Census of 1920.

Animals and Animal Products	*Number*	*Value*
Horses	3,976	$380,613
Mules	2,961	360,553
Beef cattle	4,234	219,798
Dairy cattle	7,634	445,839
Sheep	1,064	15,650
Swine	13,216	169,937
Poultry	96,984	91,672
Eggs and chickens	.....	224,981
Dairy products	.....	222,237
Wool	3,066 lbs.	1,500

The report gives the total value of livestock as more than 1½ million dollars.

SOIL FORMATION

GEOLOGICAL HISTORY

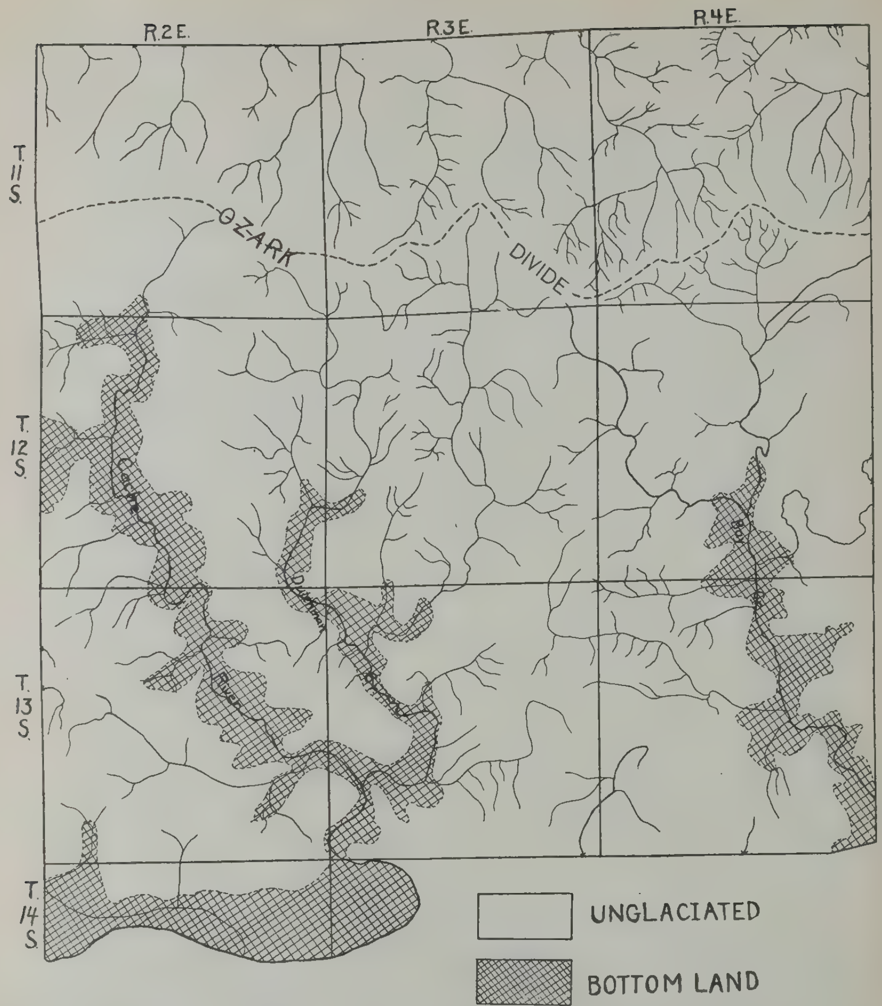
Johnson county lies mostly within a belt of high, rough land that is commonly referred to as a spur of the Ozarks which traverses the near-southern extremity of the state. This rugged area is about 35 miles wide along the Mississippi river in Illinois and covers the whole of Union, the southern part of Jackson, and the northern part of Alexander counties. It extends in a slight northeasterly direction across Johnson county, gradually narrowing until its terminus is reached in the hills of Gallatin county bordering the Ohio river. This uplift rises abruptly from the surrounding country, reaching altitudes of 800 to 1,000 feet above sea level. The region is rough and hilly, not only because of the abruptness with which it rises from the surrounding plains, but also because the agencies of weathering have been at work for a long period of time and an immense amount of erosion has taken place. The hard rocks which are exposed on the surface have been identified as those formed in the Paleozoic era, undoubtedly the oldest geologic formation now exposed in the state.

The natural accumulation of soil material in an unglaciated region, such as Johnson county, is brought about by the disintegration and partial decomposition of the surface rocks in place. This natural breaking down is going on slowly but constantly, owing to the agencies of weathering, such as freezing and thawing, wind, rainfall, and chemical action of various kinds. This accumulation was, for the most part, supplemented by a blanket of water- and wind-transported material, known as loess, deposited during and following the Glacial period. It is one of the most important sources of the soil material.

During the Glacial period, snow and ice accumulated in the region of Labrador and to the west of Hudson bay to such an extent that the mass pushed outward from these centers, chiefly to the south. At least six different ice advances occurred, which were separated by long periods of time. Recent evidence points to the fact that all these glacial advances touched Illinois. None of them, however, came any farther south than the northern boundary of Johnson county. The ice pushing outward gathered up all sorts and sizes of materials, including clay, silt, sand, gravel, boulders, and even immense masses of rock. These materials were ground together and against the surface over which they moved, thus producing an immense amount of fine-grained material known as rock flour. The flood waters from the glaciers carried large quantities of this rock flour and deposited it over the flood plains, or bottom lands. When conditions became such that the volume of flood water decreased, the streams regained their former channels and a portion of the sediment was picked up by the wind and deposited over the upland as dust. This dust, or wind-blown material, is called loess. Johnson county was covered by a deposit of loess which now varies from 1 to 20 feet in depth. It was doubtless at one time more uniform in depth, but erosion has removed large amounts of it, frequently exposing the old residual soil material and in many places the rock itself. In other places, altho erosion has not entirely removed all the loess, it has become so mixed with the residual material that the soil material might be termed residuo-loessial or residuo-aeolial.

EFFECT OF WEATHERING AND OTHER AGENCIES

The soil material was very uniform in color and texture thruout its depth in the earlier periods of its existence. The agencies of weathering, both physical and chemical, acting on the soil material, caused the leaching of certain minerals, the accumulation of others, and the movement of particles into layers, zones, or horizons. This, together with the addition of organic matter from the decay of roots and other plant growth, formed the soil. The accumulation of organic matter has not been great in the soils of Johnson county because of the heavy forest growth which covered this area for many years. Forest vegetation does not favor the accumulation of organic matter because the residues from timber, such as leaves, twigs, dead trees and roots are either destroyed by forest fires or suffer almost complete decay thru exposure to the oxygen of the air and to fungi and other organisms. The weathering forces, acting upon the soil material, bring about the formation of a true subsoil or accumulated zone. This zone, or stratum, is found at a depth of 16 to 20 inches in Johnson county and its character, as regards its degree of plasticity and compaction, is important because of its relation to underdrainage.



MAP SHOWING THE DRAINAGE COURSES OF JOHNSON COUNTY

The alluvial soils found in the bottom lands along the streams are made up largely of material brought down from the uplands of the immediate vicinity. This, of course, is mixed to a greater or less extent with organic matter. In the broader bottom lands the wet condition of the soil has developed a grayish color that is characteristic of the bottom-land soils of this region. In areas where backwater stood, the finest sediment was deposited and this constitutes the clay which is now found in the swampy, poorly-drained lowlands.

PHYSIOGRAPHY AND DRAINAGE

The topography of Johnson county is generally rough and hilly. There is but little level, or nearly level, land except in the bottom land. About 67 per-

cent of the county has been cut up into hills and narrow valleys, which, on account of their excessive slope and large run-off, have enabled the small streams to cause an immense amount of erosion. The lowest part of the county is about 340 feet above sea level, which gives a relief of approximately 450 feet in the county. Numerous perpendicular rock cliffs occur in a belt about four miles wide south of the crest of the Ozark ridge, that extends in an easterly-westerly direction across the northern part of the county.

The following figures give the altitude of certain places in the county: Belknap, 344 feet; Bloomfield, 400; Buncombe, 504; Cypress, 372; Goreville, 715; Grantsburg, 357; New Burnside, 700; Ozark, 668; Parker, 500; Ridenhower, 359; Tunnel Hill, 640; Vienna, 369; West Vienna, 500.

Johnson county lies in four distinct drainage basins, namely, those of Big Bay creek and Cache, Big Muddy, and Saline rivers. Big Bay creek drains about two townships in the southeastern corner of the county. Cache river drains all the remaining territory south of the crest of the Ozark ridge. Both these streams pass thru extensive bottom lands and swamps, and because of the large amount of surface drainage they overflow frequently. The northern and northeastern parts of the county drain into Saline river. All three of the above streams are tributaries of the Ohio river. A small portion of the northwest corner drains north into Big Muddy river, thence to the Mississippi.

With the exception of the broad swamps and bottom lands, the county is well drained. The difficulty is not in getting the water off, but rather in keeping the soil from eroding off with the drainage water. Several drainage projects have been completed in the broad stream valleys, which have reclaimed a large amount of valuable land in the swampy lowlands. Numerous meanders have been developed in the large streams which have nearly reached the base level of erosion. Cache river actually flows about 28 miles in covering a distance of six miles. This makes it difficult to keep the dredge ditches free from brush, logs, and other debris which destroy their efficiency and soon ruin them.

SOIL GROUPS

The soils of Johnson county are divided into the following groups:

Upland Timber Soils, including all the upland areas which are now or were formerly timbered, except those areas on which the loess has been almost or entirely removed.

Residual Soils, including rock outcrop areas, and soils formed in place thru weathering of rocks.

Swamp and Bottom-Land Soils, including the overflow lands or flood plains along streams, the swamps, and the poorly drained lowlands.

Table 1 gives a list of the soil types found in Johnson county, the area of each type in square miles and in acres, and its percentage of the total area of the county.

For explanation concerning the classification of soils and the interpretation of the map and tables, the reader is referred to the first part of the Appendix to this report, beginning on page 19.

TABLE 1.—SOIL TYPES OF JOHNSON COUNTY

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	Upland Timber Soils (100)			
134	Yellow-Gray Silt Loam	44.18	28,275	13.15
135	Yellow Silt Loam	206.97	132,461	61.60
		251.15	160,736	74.75
	Residual Soils (000)			
098	Stony Loam	12.98	8,307	3.86
099	Rock Outcrop	7.12	4,557	2.12
		20.10	12,864	5.98
	Swamp and Bottom-Land Soils (1300)			
1331	Deep Gray Silt Loam	43.50	27,840	12.94
1361.1	Mixed Fine Sandy Loam	16.59	10,618	4.94
1315	Drab Clay	4.66	2,982	1.39
		64.75	41,440	19.27
	Total	336.00	215,040	100.00

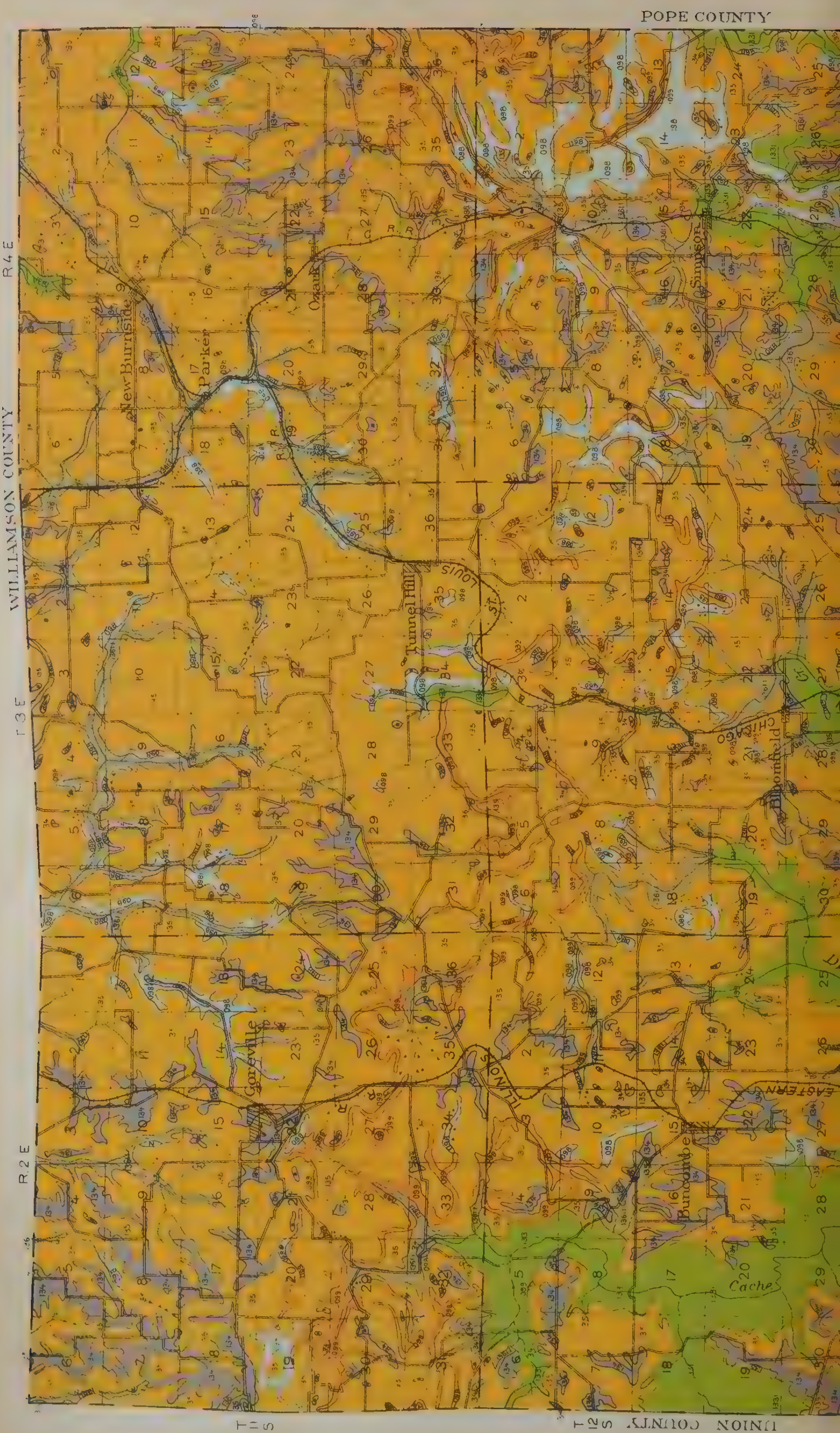
INVOICE OF THE ELEMENTS OF PLANT FOOD IN JOHNSON COUNTY SOILS

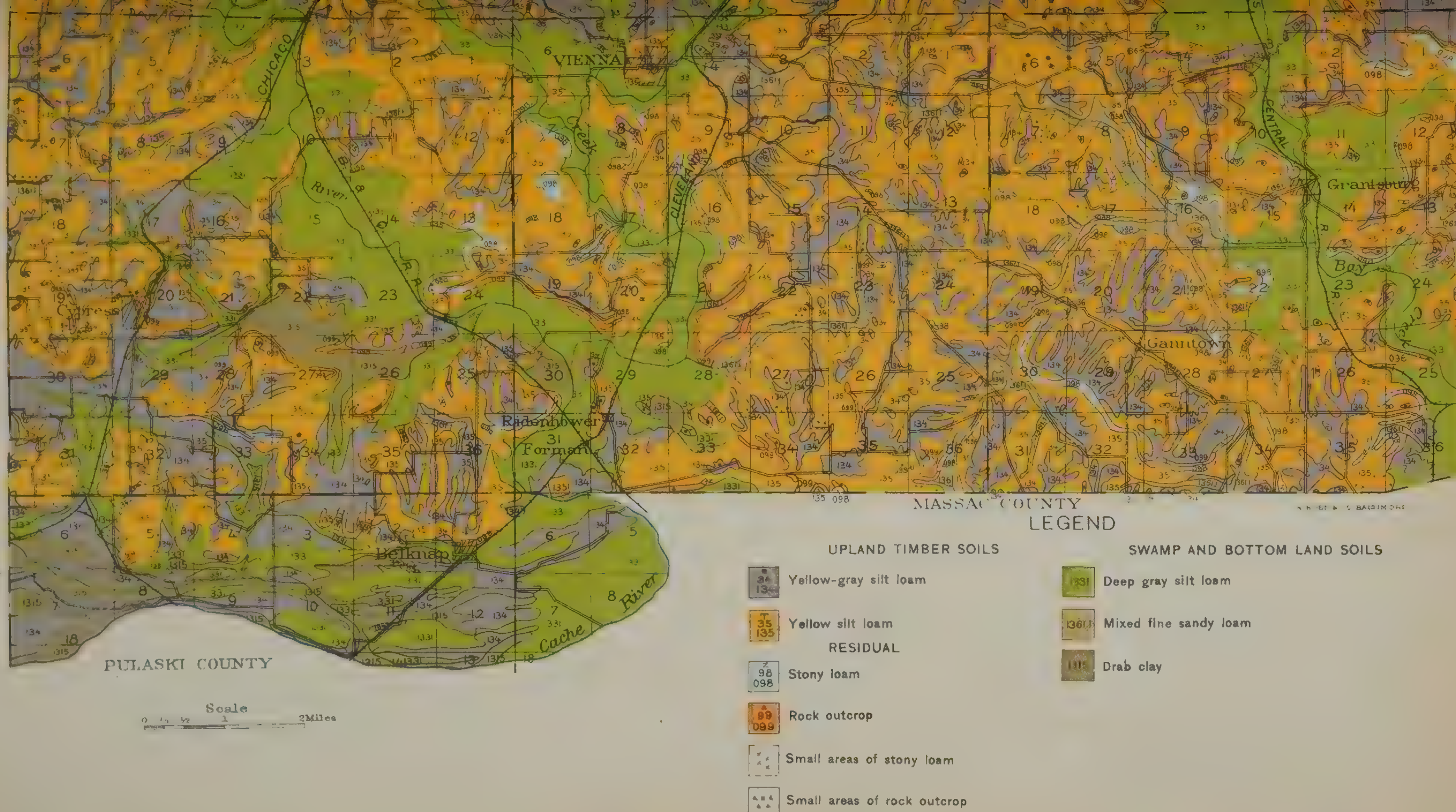
In order to obtain a knowledge of its chemical composition, each soil type is sampled in the manner described below and subjected to chemical analysis for its important plant-food elements. For this purpose samples are taken usually in sets of three to represent different strata in the top 40 inches of soil; namely an upper stratum (0 to 6⅔ inches), a middle stratum (6⅔ to 20 inches), and a lower stratum (20 to 40 inches). These sampling strata correspond approximately, in the common kinds of soil, to 2,000,000 pounds per acre of dry soil in the upper stratum, to two times this quantity in the middle stratum, and to three times in the lower stratum.

This, of course, is a purely arbitrary division of the soil section, very useful in arriving at a knowledge of the quantity and distribution of the elements of plant food in the soil, but it should be borne in mind that these strata seldom coincide with the natural strata as they actually exist in the soil and which are referred to in describing the soil types as surface, subsurface, and subsoil. By this system of sampling we have represented separately three zones for plant feeding. The upper, or surface layer, includes at least as much soil as is ordinarily turned with the plow, and this is the part with which the farm manure, limestone, and other fertilizing materials are incorporated.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled. It should be understood, however, that the rate of liberation from their insoluble forms is governed by many factors and is therefore not necessarily proportional to the total amounts present.

For convenience in making application of the chemical analyses, the results as presented here have been translated from the percentage basis and are given in the accompanying tables in terms of pounds per acre. In this, the assump-


POPE COUNTY
WILLIAMSON COUNTY
UNION COUNTY
R 4 E
R 3 E
R 2 E
New Burnside
Parker
Ozark
Tunnel Hill
Simpson
Bloomfield
Goreville
Buncombe
Cache
ST. LOUIS
CHICAGO
ILLINOIS
EASTERN



SOIL SURVEY MAP OF JOHNSON COUNTY

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

tion is made that, for ordinary types, a stratum of dry soil of the area of an acre and 6⅔ inches thick weighs 2,000,000 pounds. It is understood that this value is only an approximation, but it is believed that it will suffice for the purpose intended. It is a simple matter to convert these figures back to the percentage basis if one desires to consider the information in that form.

Because of the extreme variation frequently found within a given soil type with respect to the presence of limestone and acidity in different strata, no attempt is made to include in the tabulated results figures purporting to represent their averages in the respective types. In examining each soil type in the field, however, qualitative tests are made which furnish general information regarding the soil reaction; and in the discussion of the individual soil types recommendations based upon these tests are given concerning the lime requirement of the respective types. Such recommendations cannot be made specific in all cases because local variations exist, and because the lime requirement may change from time to time, especially under cropping and soil treatment. Therefore, it is often desirable to determine the lime requirement for a given field, and in this connection the reader is referred to page 26 of the Appendix.

THE UPPER SAMPLING STRATUM

In Table 2 are reported the amounts of organic carbon (which serves as a measure of the total organic matter), and the total quantities of nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium in 2 million pounds of the surface soil of each type in Johnson county.

In connection with this table, attention is called to the variation among the soil types with respect to their content of the different plant-food elements. It will be seen from the analyses that variations in the organic carbon content of the different soils are accompanied by a similar variation in the nitrogen content. The organic carbon content is usually from 10 to 12 times that of the total nitrogen. This close relationship is explained by the well-established facts that all soil organic matter contains nitrogen and also that most of the soil nitrogen (usually 98 percent or more) is present in a state of organic combination. This close relationship is also maintained in the middle and lower sampling strata. The organic matter and the accompanying nitrogen show considerable variation in the different soil types, tho in no case are the amounts high. The largest amount of organic carbon, 55,640 pounds an acre in the Drab Clay, Bottom, is about equal to that found in the Brown Silt Loam of the corn belt. The corresponding nitrogen content is 4,900 pounds an acre. The smallest amounts of these two elements are found in Stony Loam, where there are 17,980 and 1,140 pounds respectively. Because of the widespread deficiency of both nitrogen and organic matter in these soils, it is particularly important to grow legume crops frequently as green manure and plow them down, in addition to conserving and using all the animal manure which can be produced.

Other elements are not so closely associated with each other as organic matter and nitrogen. However, there is some degree of correlation between sulfur, another element used by growing plants, and organic carbon. This is because a considerable, tho varying, proportion of the sulfur in the soil exists in the organic form, that is, as a constituent of the organic matter. The sulfur

content of Johnson county soils is rather low; it ranges, in the surface soil, from 220 pounds to 860 pounds an acre. This is only partly accounted for by the low organic matter. Another factor is the atmospheric supply; sulfur escapes into the air in the gaseous products from the burning of all kinds of fuel, particularly coal. The gaseous oxid of sulfur is soluble in water and consequently it is dissolved out of the air by rain and brought to the earth. In regions of large coal consumption, the amount of sulfur thus added to the soil is relatively large. At Urbana, as a seven-year average, there was added to the soil by the rainfall, 3.5 pounds of sulfur an acre a month. Similar observations at the Unionville field in Massac county, during the season of 1922, showed a precipitation of less than one pound of sulfur in a month. These facts should not be taken as evidence that sulfur is a limiting factor in crop production, but it would seem that it is more likely to become one in Johnson county than in regions of more abundant supply. A number of fertilizing materials, such as sulfate of ammonia (a nitrogen fertilizer frequently used for fruit trees) acid phosphate, and potassium sulfate, contain sulfur. The use of any of these materials aids in the maintenance of a sulfur supply for the use of growing crops. (See Appendix, page 31.)

All the soils of the county are well supplied with potassium, the amounts present in the surface soil ranging from 21,340 pounds to 34,860 pounds an acre. As indicated by the experiments at Unionville, in Massac county, the soil potassium of the Yellow-Gray Silt Loam becomes available in the soil rapidly enough to meet the needs of some crops but not of corn and cotton, at the present level of production. These crops have responded to potassium fertilization. In the case of seed cotton, the average annual gain from potassium amounted to 193 pounds, or 73 percent, as compared with a plot otherwise similar but receiving no potassium. The increase in the yield of corn has averaged 5 bushels an acre a year for the potassium treatment, or 13.4 percent.

The phosphorus content of these soils is above the average for the corresponding types. The minimum amount found, namely, 890 pounds an acre in Yellow Silt Loam, is exceeded in the same soil type in only three counties of the twenty-eight for which reports have been published. The largest amount of phosphorus, 1,480 pounds an acre, is found in Drab Clay, Bottom.

As contrasted to the phosphorus supply in these soils, the calcium and magnesium contents are very low. Yellow Silt Loam, with but one exception contains, in the surface soil, the smallest quantity of both calcium and magnesium shown in any of the previous soil reports. These amounts are 4,630 and 3,370 pounds an acre, respectively. The other soil types in the county, except Drab Clay, are all comparatively low in calcium and magnesium. Because of the small amount of magnesium required by growing plants it is doubtful, even in soils as low as these, if this element ever becomes a limiting factor in crop growth. This is not true, however, of calcium, which is taken up from the soil in much larger amounts by crop plants. While low calcium content is not always associated with soil acidity, it very frequently is, as in this county, in which practically all the soils are more or less acid. This is more particularly noticeable in the lower strata, which are much more strongly acid than the surface soil and also contain proportionately less calcium. However, since limestone contains 40 percent of cal-

cium, which is easily available to crop plants, the calcium problem is automatically taken care of by additions of lime to correct acidity.

THE MIDDLE AND LOWER SAMPLING STRATA

In Tables 3 and 4 are recorded the amounts of the plant-food elements in the middle and lower sampling strata. In comparing these strata with the upper stratum, or with each other, it is necessary to bear in mind that the data as given for the middle and lower sampling strata are on the basis of 4 million and 6 million pounds of soil, and should therefore be divided by two and three, respectively, before being compared with each other or with the data for the upper stratum, which is on a basis of 2 million pounds.

With this in mind, it will be noted in comparing the three strata with each other, that all the soil types diminish rather rapidly in organic matter and nitrogen with increasing depth. Ordinarily, the percentages of the other elements remain about the same, or increase slightly in the lower strata. But we do not find this to be the case in Johnson county. Only the potassium remains approximately constant in the three strata. The percentages of sulfur and calcium are markedly lower in both the lower strata, while those of phosphorus and magnesium show considerable increase. This is especially true of magnesium, which is more than twice as concentrated in the middle and lower strata as in the surface.

These relationships may be explained by the great amount of leaching to which the soil has been subjected on account of its age and the comparatively heavy rainfall. Sulfur and calcium are fairly soluble and consequently have been leached away more rapidly than the soil mass as a whole. Sulfur also, by virtue of its relation to organic matter, may be expected to diminish with increasing depth. Phosphorus and magnesium, on the other hand, are much less soluble, and since both are readily fixed by the soil in insoluble forms, they have therefore tended to accumulate in the lower levels. It is a well-established fact that magnesium will replace calcium in minerals such as are found in the soil. It would therefore appear that magnesium, which is dissolved near the surface, as it percolates down thru the soil displaces calcium from its mineral combinations in the lower layers, so that the latter is leached away while the magnesium itself becomes fixed. Potassium, by virtue of its very low solubility, has not dissolved and passed downward to an extent that would appreciably affect the relative amounts in the different layers. These statements do not apply to the bottom-land soils, where the effects of overflow largely offset the effects of leaching.

It is frequently of interest to know the total supply of a plant-food element accessible to the growing crops. While it is impossible to obtain this information exactly, especially for the deeper-rooted crops, it seems probable that practically all the feeding range of the roots of most of our common field crops is included in the upper 40 inches of soil. By adding together for a given soil type, the corresponding figures in Tables 2, 3, and 4, the total amounts of the respective plant-food elements to a depth of 40 inches may be ascertained.

No very wide range of variation with respect to composition is found to occur in the sub-layers or in the top layers of the various soil types, except as between upland and bottom soils. The tables reveal, however, that there is a

considerable variation with respect to the relative abundance of the various elements within a given soil type as measured by crop requirements. We may compare in this way two extreme soil types in the county, namely, Drab Clay, Bottom, and Yellow-Gray Silt Loam, Upland. The respective amounts of nitrogen in the two soils to a depth of 40 inches are 16,360 and 5,930 pounds an acre, which is equivalent to the nitrogen contained in the same number of bushels of corn, since a bushel of corn contains approximately a pound of nitrogen. The Drab Clay thus contains nearly three times as much of this element as the Yellow-Gray Silt Loam. With regard to the phosphorus and potassium contents of the two soil types, there is no significant difference; Drab Clay contains 6,700 pounds of phosphorus, which is equivalent to the amount in 39,500 bushels of corn and Yellow-Gray Silt Loam 6,670 pounds, which is equivalent to 39,300

TABLE 2.—PLANT-FOOD ELEMENTS IN THE SOILS OF JOHNSON COUNTY ILLINOIS
UPPER SAMPLING STRATUM: ABOUT 0 TO 6⅔ INCHES

Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland-Timber Soils (100)							
134	Yellow-Gray Silt Loam	19,470	1,960	970	390	31,420	4,620	4,010
135	Yellow Silt Loam	20,240	1,950	890	390	30,560	4,630	3,370
	Residual Soils (000)							
098	Stony Loam	17,980	1,140	940	220	21,340	3,200	3,040
	Swamp and Bottom-Land Soils (1300)							
1331	Deep Gray Silt Loam	28,490	2,970	1,400	490	33,700	7,220	6,220
1361.1	Mixed Fine Sandy Loam[1]							
1315	Drab Clay	55,640	4,900	1,480	860	34,860	14,320	14,220

LIMESTONE AND SOIL ACIDITY.—In connection with these tabulated data, it should be explained that the figures for limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in the form of numerical averages reliable information concerning the limestone requirement for a given soil type. A general statement, however, will be found concerning the lime requirement of the respective soil types in connection with the discussions which follow.

[1]Chemical analyses are not included for Mixed Fine Sandy Loam on account of the heterogeneous character of this type.

bushels of corn. The total amounts of potassium in the two soil types, are 208,260 and 202,310 pounds, respectively, which are equivalent approximately to the amounts in 1,096,000 and 1,065,000 bushels of corn. There is wide variation in the calcium content, the amounts being 96,140 pounds in Drab Clay and 21,420 in Yellow-Gray Silt Loam. Since a ton of red clover hay contains approximately 29 pounds of calcium, these two soils contain as much calcium as would be removed in 3,310 and 740 tons of red clover hay, respectively.

The above statements are not intended to imply that it is possible to predict how long it might be before a certain soil would become exhausted under a given system of cropping. Neither do the figures necessarily indicate the immediate procedure to be followed in the improvement of a soil, for other factors enter into consideration, aside from merely the amount of plant-food elements

TABLE 3.—PLANT-FOOD ELEMENTS IN THE SOILS OF JOHNSON COUNTY, ILLINOIS
MIDDLE SAMPLING STRATUM: ABOUT 6⅔ TO 20 INCHES

Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phos-phorus	Total sulfur	Total potas-sium	Total magne-sium	Total calcium
	Upland Timber Soils (100)							
134	Yellow-Gray Silt Loam..	13,780	2,000	2,220	660	67,580	14,900	6,550
135	Yellow Silt Loam.......	16,740	2,140	1,860	440	65,420	12,980	4,690
	Residual (000)							
098	Stony Loam...........	16,680	1,640	2,640	480	44,320	10,480	4,600
	Swamp and Bottom-Land Soils (1300)							
1331	Deep Gray Silt Loam...	23,530	2,780	2,090	560	64,770	13,630	10,050
1361.1	Mixed Fine Sandy Loam[1]							
1315	Drab Clay.............	70,600	6,000	2,640	1,240	70,440	37,120	31,400

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1]Chemical analyses are not included for Mixed Fine Sandy Loam on account of the heterogeneous character of this type.

present in the soil. Much depends upon the nature of the crops to be grown, as to their utilization of plant-food materials, and much depends upon the condition of the plant-food substances themselves as to their availability. Finally in planning the detailed procedure for the improvement of a soil there enter for consideration all the economic factors involved in any fertilizer treatment. Such figures do, however, furnish an inventory of the total stocks of the plant-food elements that can possibly be drawn upon, and in this way contribute fundamental information for the intelligent planning, in a broad way, of systems of soil management for conserving and improving the fertility of the land.

TABLE 4.—PLANT-FOOD ELEMENTS IN THE SOILS OF JOHNSON COUNTY, ILLINOIS
LOWER SAMPLING STRATUM: ABOUT 20 TO 40 INCHES

Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phos-phorus	Total sulfur	Total potas-sium	Total magne-sium	Total calcium
	Upland Timber Soils (100)							
134	Yellow-Gray Silt loam..	10,070	1,970	3,480	530	103,310	32,300	10,860
135	Yellow Silt Loam.......	11,020	1,790	2,940	370	104,570	28,940	9,800
	Residual Soils (000)							
098	Stony Loam[1]..........							
	Swamp and Bottom-Land Soils (1300)							
1331	Deep Gray Silt Loam...	21,260	2,950	2,680	850	91,720	21,110	16,270
1361.1	Mixed Fine Sandy Loam[2]							
1315	Drab Clay.............	77,880	5,460	2,580	1,260	102,960	58,920	50,520

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1]No sample could be collected on account of the stony nature of this stratum.
[2]Chemical analyses are not included for Mixed Fine Sandy Loam because of the heterogeneous character of this type.

DESCRIPTION OF SOIL TYPES

UPLAND TIMBER SOILS

The upland timber soils include all the upland areas that are now or were formerly timbered, with the exception of those areas which are classified as Stony Loam or Rock Outcrop, from which the loess has been partially or entirely removed by erosion. The timber soils are characterized by a brownish yellow, yellow, or yellowish gray color. The low percentage of organic matter which characterizes these soils is the result of long-continued growth of forests. Prairie grasses, which furnish large amounts of organic matter, do not grow to any extent in the shaded timber areas. The organic material in forests, such as leaves and twigs, does not accumulate in the soil, but is either burned or suffers almost complete decay. Moreover, the organic matter that may have accumulated in the soil before the timber began growing is slowly removed by decomposition and leaching. The result is that the contents of organic matter and nitrogen in the timber soils are low.

Yellow-Gray Silt Loam (134)

The growth of forest trees has been an important factor in the development of Yellow-Gray Silt Loam. Timber ordinarily starts along streams and on the better drained areas and gradually spreads. No doubt some of the area now classified as Yellow Silt Loam was formerly Yellow-Gray Silt Loam, but erosion, which is active in this region, has removed much of the soil material, making many of the formerly undulating or rolling areas rough and broken. Yellow-Gray Silt Loam occupies a total area of 44.18 square miles, or more than 13 percent of the area of the county. It occurs in irregular tracts and is found either as flat to undulating bench land along streams, or as rolling areas on the comparatively level tops of ridges. Many isolated areas occur in the county, but the major portion of the type is found in the southern tier of townships.

There are two distinct phases of Yellow-Gray Silt Loam in the county, corresponding to the differences in topography and location as noted above. The flat to gently undulating phase is found principally along Cache river and its tributaries in the vicinity, and south of Vienna. This phase of the type occurs as a bench-like formation. The rolling phase of the type occurs as irregular areas on the comparatively level tops of ridges scattered thruout the county. As indicated, its topography is rolling, often breaking off suddenly into an exceptionally steep phase of Yellow Silt Loam.

The surface soil of the undulating phase of Yellow-Gray Silt Loam, 0 to 5 inches, is a brownish yellow, friable, coarse silt loam, often containing an appreciable amount of medium and fine sand. The subsurface soil, 5 to 16 inches, is a friable, mottled, grayish yellow silt loam, and also contains a perceptible amount of fine sand. The subsoil is divided into two distinct layers. The upper stratum, 16 to 36 inches, is a compact, mottled yellow silt loam, often rather plastic when wet; the lower stratum is friable and is usually brighter yellow in color than the upper stratum.

The rolling phase of the type differs from the undulating phase in that the surface soil rarely exceeds 2 inches in depth, a high percentage of fine sand is uniformly distributed thruout the soil section, and the transition from one

stratum to the next is gradual. The upper subsoil, however, is compact and well developed. The depth to bed rock varies from about 5 to 20 feet.

Management.—This type is very low in organic matter and nitrogen and is somewhat acid, tho apparently not strongly so. The degree of acidity generally increases with increasing depth to about 6 or 7 feet. Red clover will not grow on this land unless it is either limed or heavily manured. Sweet clover will not grow without lime. Alfalfa can be grown with fair success following sweet clover; however, it is not a sure crop because of the excessive heaving which often occurs during the winter and early spring and the tendency to die out during the hot dry weather in July and August. Cowpeas do well without lime, and mixed clover and timothy hay yields well following the application of 2 to 4 tons of limestone per acre. It is advisable to secure the assistance of the county farm adviser or of the Experiment Station in determining the amount of limestone to apply since the need varies from place to place. The fineness of the stone is also an important factor in determining the rate of application.

Cotton may be grown on this type, particularly on the bench-like portion of the type, but it is necessary to handle the soil and crop in such a way that a vigorous early growth is secured, in order that the crop may mature before frost. The reader is referred to Illinois Circular 279 for special directions regarding the fertilization and management of the cotton crop.

Unless the land is well treated, corn is not a good crop for this soil because the seasonal conditions are very often such that the crop suffers from drouth. The average yield of wheat in the county is only about 11 bushels an acre, and this yield is not far from the average for this soil type; moreover, no material increase in yield can be expected unless provision is made for improving the soil.

In the management of this type, a rotation should be adopted in which clover is grown at frequent intervals. All manure should be conserved and applied for corn or on the timothy sod. Information is not available upon which to base definite recommendations regarding the use of other fertilizing materials. Results secured on the Elizabethtown experiment field in Hardin county, which is located on soil that is similar to this type, indicate that the growth of sweet clover is very much increased by rock phosphate and that the following corn crop shows a similar response, probably largely because of the increased clover growth. Acid phosphate has given larger increases in the yield of wheat than has rock phosphate. It is suggested that a trial be made of either, or both, of these phosphates, after the need for lime, nitrogen, and fresh organic matter has been met. Rock phosphate should be applied at the rate of at least 1,000 pounds per acre and plowed down for wheat with some kind of organic matter. Acid phosphate should be applied at the rate of about 300 pounds per acre with a drill, or broadcasted after plowing for wheat and worked into the soil as the seed bed is being prepared. The use of potash salts may prove profitable when applied for corn or cotton, but sufficient information is not now available to justify any definite recommendations.

Yellow Silt Loam (135)

Yellow Silt Loam is by far the most common soil type and occurs thruout the entire county. It covers an area of 206.97 square miles, or nearly 62 percent

FIG. 1.—A FIELD IN WHICH EROSION IS STARTING ITS DESTRUCTIVE WORK
This view was taken on a farm adjoining the old Vienna experiment field.

of the entire area. This type varies in topography from rolling to extremely rough and hilly, and includes much land which should not be cultivated. On the steeper slopes, much of the loessial soil material has been removed by erosion, so that the soil is constituted either of the residual material derived from the weathered rock or of a mixture of this with loessial material. The soil of these areas from which the loessial material has been removed is a red or reddish yellow clay mixed with some angular cherty or flinty pebbles. Slopes facing the north are frequently very abrupt, while those to the south are more gradual. Much of this land is so badly gullied or washed that it has been abandoned agriculturally. Land of this character should never have been cleared of its protecting forests. It would, no doubt, be more economical to return this rough, badly eroded land to timber and thus in time place it on a paying basis, rather than to allow it to waste away. The less-broken portions of this type can

FIG. 2.—THIS IS THE SAME FIELD AS SHOWN IN FIG. 1, BUT TEN YEARS LATER

be utilized for pasturing and orcharding. Because of its yellow color, this type of soil is commonly termed clay, and the type as a whole spoken of as clay hills. In reality, it contains very little clay, much less than other soil types in the county.

Erosion is so active on the area occupied by Yellow Silt Loam that a true surface soil is seldom found. Where present, it is but 2 or 3 inches deep, and is a brownish yellow, friable, silt loam. It often contains much fine sand. The subsurface also has been in part or entirely removed from many areas, and it may therefore be present in its entirety or it may be partly or wholly absent. On the areas which have not been subjected to more recent erosion, it occurs as a stratum about 18 inches thick, and consists of a light grayish yellow, friable, silt loam. It always contains an appreciable amount of fine sand. The subsoil when present consists of two strata: the upper stratum, to a depth of 50 inches, is a compact, strongly mottled, yellow silt loam, or less frequently, clay loam; the lower, below 50 inches, is a friable, mottled yellow silt loam. The thickness of this lower subsoil stratum is determined by the amount of erosion that has taken place. It varies from a few inches to about 14 feet.

Management.—The management of this type presents peculiar difficulties. Erosion is severe and constant watchfulness is necessary to prevent serious damage being done to tilled fields by gullying and sheet washing. The reader is referred to Illinois Circular 290 for a discussion of terracing as one means of controlling erosion, and to Illinois Bulletin 207 for a thoro discussion of the general subject of erosion. The removal of most of the timber, and the subsequent rapid disappearance of the small amount of organic matter which had accumulated on the surface of the soil, left this land with nothing to protect it from washing. Much of the area is fit only for timber and pasturing, certain

FIG. 3.—BLACK LOCUSTS GROWING ON BADLY ERODED LAND
Much of this rough land might well be devoted to the production of timber rather than the growing of cultivated crops.

portions may be used for orcharding, and the less steep slopes may be farmed successfully if precautions are taken to prevent erosion. The soil is invariably acid, and is very low in nitrogen and organic matter. Where limestone can be applied, sweet clover is an excellent crop to be grown for pasture, or it may be used as a combination hay and pasture crop. The soil is usually saturated with water in the spring and stock should be kept off until it becomes firm enough not to be injured by tramping. Cowpeas grow well without any lime and make excellent hay for dairy cattle and other stock.

There are many areas in the county which are so isolated on account of bad roads as to make it impossible to apply limestone unless it can be secured from local crushers. In case a limestone outcrop is available but no crusher can be secured, the practicability of converting the stone to a usable condition by home burning is worth investigating.

No practicable way is now known for improving this worn hill land unless some lime material can be applied. There may be possibilities of doing this by the introduction of leguminous plants not now common to the region, which will grow in acid soils. These possibilities have, however, not been investigated, and until they are, no adequate suggestions can be made for building up this soil unless lime in some form can be applied.

After the nitrogen and organic deficiencies of this soil have been met, in part at least, then the advisability of using phosphates and other fertilizers profitably should be determined by trials on limited areas.

RESIDUAL SOILS

These soils are formed in part by the weathering of the underlying rocks that have been exposed by erosion, and this weathered material has been more or less mixed with the wind-blown loessial material. This group of soils occurs chiefly on the south approach to the crest of the Ozark ridge. Their topography is extremely rough.

Stony Loam (098)

Stony Loam occurs principally in Simpson township, but small areas occur in almost every township. The total area is about 13 square miles. The stones occurring are principally sandstone and they vary in size from a few inches to several feet in diameter. These stones are mixed with more or less fine soil material, fine sand almost always forming one-third or more of the total. Occasional rock ledges are found in these areas that are too small to be shown separately. This type is adapted only to forestry and pasture.

Rock Outcrop (099)

Rock Outcrop occurs most abundantly in an east-west belt across the county just south of the crest of the Ozark ridge. The total area of Rock Outcrop is 7.12 square miles. The width of the individual areas is often exaggerated on the soil map in order to show the perpendicular cliffs.

The outcropping rock, especially that found in the northern part of the county, is principally sandstone, known as Pennsylvanian rocks. Outcrops of limestone, Mississippian rocks, occur in the vicinity of Vienna and others occur

near Cypress. These limestone outcrops may well be used as sources of limestone for agricultural purposes. At the present time limestone is being crushed for that purpose at White Hill. This limestone contains carbonates equivalent to about 88 or 90 percent calcium carbonate. Outcrops of shale also occur in connection with some of the sandstone on the south side of the Ozark ridge.

SWAMP AND BOTTOM-LAND SOILS

This group of soils includes the bottom land along streams, the swamps, and the poorly drained lowlands. Much of the soil, therefore, is of alluvial formation and the land is largely subject to overflow. The overflow is difficult to control because of the heavy rainfall and quick run-off from the surrounding hills. The run-off in this region is estimated to be 50 percent of the total rainfall, so the streams must carry large amounts of water. Dredging, resulting in the straightening, widening, and deepening of the stream channels, has been carried out in some places, thereby materially decreasing the amount of damage by overflow. The completion of Post Creek Cut-Off, which shunts the water from Cache river directly to the Ohio, gives a much better outlet than any heretofore had. This has made the smaller dredge ditches in the county more efficient.

For many years the lowlands along Cache river in Cache township, (Township 14 South, Range 2 East) have been shallow ponds or lakes, and still are during wet seasons. Backwater was forced into the ponds by the streams, and from this backwater, the finer soil particles were deposited. This deposit constitutes the dark heavy soil of the present swampy areas. The bottom-land soils in Johnson county constitute nearly 20 percent of the total area of the county.

Deep Gray Silt Loam (1331)

Deep Gray Silt Loam is the most extensive bottom-land type in the county, occupying an area of 43.5 square miles, or 12.94 percent of the total area of the county. It occurs principally along the courses of the three largest streams, Cache river in the west, Dutchman creek in the center, and Bay creek in the east. Its distribution along those streams is irregular, varying from a few rods to nearly two miles in width.

The surface soil of Deep Gray Silt Loam is a yellowish gray, friable, mealy, silt loam, containing considerable fine sand. It is rather variable, however, ranging from a sandy to a clayey phase, depending on its position with reference to the stream channel. Near the channel, where the overflow is frequent, the soil is more sandy. Away from the channel, where there is practically no current, the soil is heavier, containing more clay. The subsurface soil is a continuation of the surface except that the yellow color gradually fades away with increasing depth, and the content of silt is more uniform. The subsoil below 18 inches is a slightly compact, gray, silty clay loam, except where the deposit is recent. Along stream channels the subsoil is more of a silty or fine sandy nature and not so compact.

Management.—Deep Gray Silt Loam is the best soil in Johnson county. It is not strongly acid and those portions which are subject to overflow will not become acid. Poor drainage characterizes the type. Means should be provided for the rapid removal of flood and other water by the construction of open

ditches and by the laying of tile drains. The organic-matter and nitrogen contents of this soil are low and are difficult to maintain on the overflow areas. Every effort should be made to increase these soil constituents by the use of legumes, manure, and crop residues. No definite fertilizer recommendation can be made at the present time, but it is suggested that, if wheat is grown, rock or acid phosphate be tried as suggested for Yellow-Gray Silt Loam (page 13). If cotton is grown, the suggestions in Illinois Circular 279 should be followed.

Mixed Fine Sandy Loam (1361.1)

Mixed Fine Sandy Loam occurs along the smaller streams and represents areas usually not over a quarter of a mile wide. It is formed of material brought down from the upland of the immediate vicinity. Whenever a big rain overflows these bottoms, the coarser material is deposited in them, while the finer is carried out into the larger bottoms of Deep Gray Silt Loam. Because of frequent overflow with the deposition of new material, this type is variable. Mixed Fine Sandy Loam covers an area of 16.59 square miles.

The surface soil to a depth of 6 or 7 inches is usually a grayish yellow, loose, fine sandy loam. The subsurface soil to a depth of about 18 inches is a loose, yellow fine sandy loam. The subsoil is a yellow, fine sandy loam mixed with some coarser material such as gravel and small rock. The average depth of the soil to the rock base is about 5 feet, but it ranges from a few inches to 10 or 12 feet.

Management.—This type is somewhat acid even tho it is practically all overflow land. The rapid removal of flood water is an important consideration in its management. It is an easily worked soil because of its high sand content, but its sandy, open character, together with its frequent flooding, makes the maintenance of nitrogen and organic matter difficult and particular attention must be given to this phase of its management.

Drab Clay (1315)

Drab Clay occurs in the swampy, poorly drained lowlands along Cache river in the southwestern part of the county. It has been formed by the deposition of the finest soil material in the backwater caused by stream overflow. It comprizes 4.66 square miles, or 1.39 percent of the area of the county.

The surface soil, 0 to 5 inches, varies from a brownish gray, sandy clay loam to a dark drab, granular, plastic clay. Its character depends on the amount of recent deposit. Near the upland and the creek channels considerable silt and sand are present, while a typical drab clay is found in the center of the areas. The subsurface to about 20 inches is a very plastic, grayish or bluish drab clay. The subsoil is a fairly plastic, yellowish gray clay.

Management.—This type is adapted only to timber production because of its swampy, plastic, and compact nature.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order intelligently to interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification used.

The type is the unit of classification and each type has definite characteristics. In establishing types, the following factors are taken into account: the character of the horizons composing the soil as to depth and thickness, physical composition, structure, organic-matter content, color, reaction, and carbonate content; the topography; the native vegetation; and the geological origin of the soil.[1]

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made whenever the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

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[1] Since some of the terms used in designating the factors which are taken into account in establishing soil types are technical in nature, the following explanations are introduced:

Horizon. A layer or stratum of soil which differs discernibly from those adjacent in color, texture, structure, chemical composition, or a combination of these characteristics, is called an horizon.

Depth and Thickness. The horizons or layers which make up the soil profile vary in depth and thickness. These variations are distinguishing features in the separation of soils into types.

Physical Composition. The physical composition, sometimes referred to as "texture," is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents: clay, silt, fine sand, sand, gravel, stones, and organic material.

Structure. The term "structure" has reference to the aggregation of particles within the soil mass and carries such qualifying terms as open, granular, compact.

Organic-Matter Content. The organic matter of soil is derived largely from plant tissue and it exists in a more or less advanced stage of decomposition. Organic matter forms the predominating constituent in certain soils of swampy formation.

Color. Color is determined to a large extent by the proportion of organic matter, but at the same time it is modified by the mineral constituents, especially by iron compounds.

Reaction. The term "reaction" refers to the chemical state of the soil with respect to acid or alkaline condition. It also involves the idea of degree, as strongly acid or strongly alkaline.

Carbonate Content. The carbonate content has reference to the calcium carbonate (limestone) present, which in some cases may be associated with magnesium or other carbonates. The depth at which carbonates are found may become a very important factor in determining the soil type.

Topography. Topography has reference to the lay of the land, as level, rolling, hilly, etc.

Native Vegetation. The vegetation or plant growth before being disturbed by man, as prairie grasses and forest trees, is a feature frequently recognized in determining soil types.

Geological Origin. Geological origin involves the idea of character of rock materials composing the soil as well as the method of formation of the soil.

Classifying Soil Types.—In the system of classification used, the types fall first into four general groups based upon their geological relationships; namely, upland, terrace, swamp and bottom land, and residual. These groups may be subdivided into prairie soils and timber soils, altho as a matter of fact this subdivision is applied in the main only to the upland group. These terms are all explained in the foregoing part of the report in connection with the description of the particular soil types.

Naming and Numbering Soil Types.—In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a more or less definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise type names which are adequately descriptive, because the profile of mature soils is usually made up of four or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "on," and when its depth exceeds 30 inches, by the word "over"; for example, Brown Silt Loam On Gravel, and Brown Silt Loam Over Gravel.

As a further step in systematizing the listing of the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been assigned an index number. The names of the areas together with their general location and their corresponding index numbers are given in the following list.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* comprizing three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciations
300 *Lower Illinoisan glaciation,* covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* found in the older or Illinoisan glaciation
1400 *Late river-bottom and swamp lands,* those of the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan

For further information regarding these geological areas the reader is referred to the general map published in Bulletins 123 and 193.

Another set of index numbers is assigned to the classes of soils as based upon physical composition. The following list contains the names of these classes with their corresponding index numbers.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the balance of the number designates the type. To illustrate: the number 1126 means Brown Silt Loam in the early Wisconsin glaciation, 434 means Yellow-Gray Silt Loam of the middle Illinoisan glaciation. These numbers are especially useful in designating very small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports in connection with the maps.

SOIL SURVEY METHODS

Mapping of Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. The field work is done by parties of two to four men each. The field season extends from early in April to Thanksgiving. During the winter months the men are engaged in preparing a copy of the soil map to be sent to the lithographer, a copy for the use of the county farm adviser until the printed map is available, and a third copy for use in the office in order to preserve the original official map in good condition.

An accurate base map for field use is necessary for soil mapping. These maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as the basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil type boundaries, together with the streams, roads, railroads, canals, town sites, and rock and gravel quarries are placed in their proper location upon the map while the mapper is on the area. With the rapid development of road improvement during the past few years, it is almost inevitable that some recently established roads will not appear on the published soil map. Similarly, changes in other artificial features will occasionally occur in the interim between the preparation of the map and its publication. The detail or minimum size of areas which are shown on the map varies somewhat, but in general a soil type if less than five acres in extent is not shown.

A soil auger is carried by each man with which he can examine the soil to a depth of 40 inches. An extension for making the auger 80 inches long is taken

by each party, so that the deeper subsoil may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by a speedometer or other measuring device, while distances in the field away from the roads are measured by pacing.

Sampling for Analysis—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. The samples for this purpose are usually taken in three depths; namely, 0 to 6⅔ inches, 6⅔ to 20 inches, and 20 to 40 inches, as explained in connection with the discussion of the analytical data on page 6.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. A fact of equal importance, not so generally recognized, is that they also differ in other characteristics such as response to fertilizer treatment and to management.

The soil is a dynamic, ever-changing, exceedingly complex substance made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, the soil cannot be considered as a reservoir into which a given quantity of an element or elements of plant food can be poured with the assurance that it will respond with a given increase in crop yield. In a similar manner it cannot be expected to respond with perfect uniformity to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance favorable for the growth of the higher plants and of the beneficial microorganisms. Good soil management under humid conditions involves the adoption of those tillage, cropping, and fertilizer treatment methods which will result in profitable and permanent crop production on the soil type concerned.

The following paragraphs are intended to state in a brief way some of the principles of soil management and treatment which are fundamental to profitable and continued productivity.

CROP REQUIREMENTS WITH RESPECT TO PLANT-FOOD MATERIALS

Ten different elements of plant food are essential for the growth and formation of every plant. These elements are: *carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, magnesium, calcium, and iron.* Some seasons in central Illinois are sufficiently favorable to allow the production of at least 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. When such crops, growing under favorable climatic and cultural conditions and uninjured by disease or insect pests, are not produced the failure is due to unfavorable soil conditions, which may result from poor drainage, poor physical condition, or from an actual deficiency in one or more of the elements of plant food.

TABLE 5.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain......	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw......	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain.......	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover.......	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs........	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain.......	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw........	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed.......	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay.......	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed.....	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay......	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay.......	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1]These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

Table 5 shows the requirements of some of our most common field crops with respect to the seven plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of any element removed from an acre of land by a crop of a given yield can easily be computed.

PLANT-FOOD SUPPLY

Of the ten elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and seven from the soil. Nitrogen, one of these seven elements obtained from the soil by all plants, may also be secured from the air by the class of plants known as legumes, in case the amount liberated from the soil is insufficient; but even these plants, which include only the clovers, peas, beans, and vetches among our common agricultural plants, are dependent upon the soil for the other six elements (phosphorus, potassium, magnesium, calcium, iron, and sulfur), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 420 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor

TABLE 6.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	...	...
Sodium nitrate	310	...	...
Ammonium sulfate	400	...	...
Raw bone meal	80	180	...
Steamed bone meal	20	250	...
Raw rock phosphate	...	250	...
Acid phosphate	...	125	...
Potassium chlorid	...	...	850
Potassium sulfate	...	...	850
Kainit	...	...	200
Wood ashes[3] (unleached)	...	10	100

[1]See footnote to Table 5.
[2]Young second year's growth ready to plow under as green manure.
[3]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

of production, then we must look for some outside source of supply. Table 6 is presented for the purpose of furnishing information regarding the quantity of some of the more important plant-food elements contained in materials most commonly used as sources of supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of plant-food elements actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such elements as calcium and phosphorus, converting them into available forms for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral elements are liberated for

the benefit of the cereal crops which follow in the rotation. Moreover, as an effect of the deep-rooting habit of these legumes, mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and supplies calcium, thus encouraging the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the unavailable organic nitrogen into available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium compounds.

Organic Matter and Biological Action.—Organic matter may be supplied thru animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant-food materials than 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the ratio of carbon to nitrogen. Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing available phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant-food elements by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant-food materials are concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than

this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter, and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement.

Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands. Remarkable success has been experienced with limestone used in conjunction with sweet clover in the reclamation of abandoned hill land which has been ruined thru erosion.

Amounts to Apply.—If the soil is acid, limestone should be applied, the initial treatment being at the rate of 2 to 6 tons an acre, according to the degree of acidity. Continue to apply limestone from time to time according to the requirement of the soil as indicated by the tests described below, or until the most favorable conditions are established for the growth of legumes, using preferably at times magnesian limestone ($CaCO_3MgCO_3$), which contains both calcium and magnesium and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone ($CaCO_3$). On strongly acid soils, or on land being prepared for alfalfa, 4 or 5 tons per acre of ground limestone may well be used for the first application.

How to Ascertain the Need for Limestone.—One of the most reliable indications as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover and alfalfa. These crops do not thrive in acid soils. Their successful growth, therefore, indicates the lack of sufficient acidity in the soil to be harmful. In case of their failure to grow the soil should be tested for acidity as described below. A very valuable test for ascertaining the need of a soil for limestone is found in the potassium thiocyanate test for soil acidity. It is desirable to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonate of calcium and magnesium. The natural occurrence of these carbonates in the

soil is sufficient assurance that no limestone is needed, and the acidity test will be negative. On lands which have been treated with limestone, however, the surface soil may give a positive test for carbonates, due to the presence of undecomposed pieces of limestone, and at the same time a positive test for acidity may be secured. Such a result means either that insufficient limestone has been added to neutralize the acidity, or that it has not been in the soil long enough to entirely correct the acidity. In making these tests, it is desirable to examine samples of soil from different depths, since carbonates may be present, even in abundance, below a surface stratum that is acid. Following are the directions for making the tests:

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol.[1] When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. The sample when tested, therefore, should be at least as dry as when the soil is in good tillable condition. For a prompt reaction the temperature of the soil and solution should be not lower than that of comfortable working conditions (60° to 75° Fahrenheit).

The Hydrochloric Acid Test for Carbonates. Make a shallow cup of a ball of soil and pour into it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of limestone or some other carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen usually costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for plant growth. These are the chemical and the biological fixation of the atmospheric nitrogen. Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of those legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for purposes other than the fixation of atmospheric nitrogen, a considerable portion of the nitrogen thus gained

[1] Since undenatured alcohol is difficult to obtain, some of the denatured alcohols have been tested for making this solution. Completely denatured alcohol made over U. S. Formulas No. 1 and No. 4,, have been found satisfactory. Some commercial firms are also offering similar preparations which are quite satisfactory.

may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes in the production of our great grain and forage crops.

It may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpea hay contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of the soil is dependent upon the origin of the soil. The removal of phosphorus by continuous cropping slowly reduces the amount of this element in the soil available for crop use, unless its addition is provided for by natural means, such as overflow, or by agricultural practices, such as the addition of phosphatic fertilizers and rotations in which deep-footing, leguminous crops are frequently grown.

It should be borne in mind in connection with the application of phosphate, or of any other fertilizing material, to the soil, that no benefit can result until the need for it has become a limiting factor in plant growth. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different materials containing phosphorus which are applied to land as fertilizer. The more important of these are bone meal, acid phosphate, natural raw rock phosphate, and basic slag. Obviously that carrier of phosphorus which gives the most economical returns, as considered from all standpoints, is the most suitable one to use. Altho this matter has been the subject of much discussion and investigation the question still remains unsettled. Probably there is no single carrier of phosphorus that will prove to be the most economical one to use under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

Bone meal, prepared from the bones of animals, appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the phosphorus, a considerable percentage of nitrogen which adds a useless expense if the material is purchased only for the sake of the phosphorus. As a source of phosphorus, steamed bone meal is preferable to raw bone meal. Steamed bone meal is prepared by extracting most of the nitrogenous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate containing about 10 to 12 percent of the element phosphorus.

Acid phosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. Besides phosphorus, acid phosphate also contains sulfur, which is likewise an element of plant food. The phosphorus in acid phosphate is more readily available for absorption by plants than that of raw rock phosphate. Acid phosphate of good quality should contain 6 percent or more of the element phosphorus.

Rock phosphate, sometimes called floats, is a mineral substance found in vast deposits in certain regions. The phosphorus in this mineral exists chemically as tri-calcium phosphate and a good grade of the rock should contain 12½ percent, or more, of the element phosphorus. The rock should be ground to a powder, fine enough to pass thru a 100-mesh sieve, or even finer.

The relative cheapness of raw rock phosphate, as compared with the treated or acidulated material, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in this form than in the form of acid phosphate, the ratio being, under the market conditions of the past several years, about 4 to 1. That is to say, under these market conditions, a dollar will purchase about four times as much of the element phosphorus in the form of rock phosphate as in the form of acid phosphate, which is an important consideration if one is interested in building up a phosphorus reserve in the soil. As explained above, more very carefully conducted comparisons on various soil types under various cropping systems are needed before definite statements can be given as to which form of phosphate is most economical to use under any given set of conditions.

Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag phosphate is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore it tends to influence the soil reaction.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating the phosphorus from raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using acid phosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the

wheat ground. It may be advantageous, however, to divide the total amount to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, which are silt loams and clay loams, are well stocked with potassium, altho it exists largely in a slowly soluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be remedied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of common soils are concerned, that, with a few exceptions, the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium salts to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part, perhaps, by the fact that the potassium removed in the crops is mostly returned in manure properly cared for, and perhaps in larger part by the fact that decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no limiting element of plant food.

In considering the conservation of potassium on the farm it should be remembered that in average live-stock farming, the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in livestock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by crop removals of the plant-food elements, calcium is often more limited in Illinois soils than is potassium, while magnesium may be occasionally. In the case of calcium, however, the deficiency is likely to develop more rapidly and become much more marked because this element is leached out of the soil in drainage water to a far greater extent than is either magnesium or potassium.

The annual loss of limestone from the soil depends, of course, upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of lime materials from the soil, it is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

Limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and with an annual return,

which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply to conditions in Illinois.

Physical Improvement of Soils

In the management of most soil types, one very important matter, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, slightly retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is undergoing destruction during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, cornstalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and cornstalks should be turned under, and not burned. There is considerable evidence indicating that on some soils undecomposed straw applied in excessive amount may be detrimental. Probably the best practice is to apply the straw as a constituent of well-rotted stable manure. Perhaps no form of organic matter acts more beneficially in producing good tilth than cornstalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of cornstalks is one and one-half times that of a ton of manure, and a ton of dry cornstalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the cornstalks during the winter and often rather late in the spring after the frost is out of the ground.

This trampling by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The effect becomes worse if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including, for the reasons discussed above, a liberal use of legumes. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations, applicable to the corn belt, which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover), or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in livestock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year	—Corn
Second year	—Cowpeas or soybeans
Third year	—Wheat (with clover)
Fourth year	—Clover
Fifth year	—Wheat (with clover)

The last rotation mentioned above allows legumes to be grown four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year	—Corn
Second year	—Wheat or oats (with clover)
Third year	—Clover
Fourth year	—Wheat (with clover)

First year	—Corn
Second year	—Corn
Third year	—Wheat or oats (with clover)
Fourth year	—Clover

First year	—Corn
Second year	—Cowpeas or soybeans
Third year	—Wheat (with clover)
Fourth year	—Clover

First year	—Wheat (with clover)
Second year	—Clover
Third year	—Corn
Fourth year	—Oats (with clover)

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year	—Corn
Second year	—Oats or wheat (with clover)
Third year	—Clover

First year	—Wheat (with clover)
Second year	—Corn
Third year	—Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year	—Oats or wheat (with sweet clover)
Second year	—Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. Or, in some cases, it may become desirable to divide the acreage of small grain and grow in the same year more than one kind. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover, especially as a green manure for building up depleted soils, as well as a pasture and haycrop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields on Soil Types Similar to those Occurring in Johnson County)

In the earlier reports of this series it was the practice to incorporate in the body of the report the results from certain experiment fields, for the purpose of illustrating the possibilities of improving the soil of various types. The information carried by such data must, naturally, be considered more or less tentative. As the fields grow older new facts develop, which in some instances may call for the modification of former recommendations. It has therefore seemed desirable to separate this experiment field data from the more permanent information of the soil survey, and embody the same in the form of a supplement to the soil report proper, thus providing a convenient arrangement for possible future revisions as further data accumulate.

The University of Illinois has operated altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the majority are still in operation. It is the present purpose to report the summarized results from certain of these fields located on types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Two Farming Systems Provided

On many of the fields the treatment provides for two distinct systems of farming, livestock farming and grain farming.

In the livestock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as corn stalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It is the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the livestock system.

Definite Crop Rotations Followed

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Standard Soil Treatment Used

The treatment applied to the plots has, for the most part, been standardized according to a rather definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grain to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, usually 200 pounds of kainit. When kainit was not available, owing to conditions brought on by the World war, potassium carbonate was used. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

THE OLD VIENNA FIELD

From 1902 to 1911 the University conducted an experiment field in Johnson county, about two miles southeast of Vienna, on land that was described at the time as "red clay, a soil typical of the hill sections of the state." The field comprized a tract of 5.6 acres of land rolling in topography, a portion of which was low and wet. It was not tile-drained.

Previous to 1902 this land had been cultivated for about fifty years, after which it was said to be still capable of producing fair crops of corn and wheat.

For the experiment work the field was laid out into three series of plots one-fifth acre in size, each series containing 5 plots. A crop rotation of wheat, corn, and cowpeas was started; but in 1905 this rotation was changed to corn, oats, wheat, and legumes. Cowpeas for plowing down were seeded in the corn at the last cultivation excepting on Plot 1. As the carrier of phosphorus, steamed bone meal was used at the rate of 200 pounds an acre a year. Potassium was applied in the form of potassium sulfate, this material being used at the annual acre rate of 100 pounds. Lime was applied in 1902 in the form of slaked lime at the rate of 1,800 pounds, and the following year limestone was added at the rate of 8 tons.

The results of these treatments are presented in Table 7, which records for each year the acre yields of all crops harvested. Table 8 presents a summary giving the average annual acre yields of the 9 corn crops and 8 wheat crops harvested after the plots had received their respective treatments.

The great need of this land for organic matter and nitrogen is brought out in these results. Organic matter and nitrogen are furnished by the legumes in

TABLE 7.—OLD VIENNA FIELD

Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1902 Corn[1]	1903 Corn	1904 Cowpeas	1905 Wheat	1906 Cow-peas[2]	1907 Corn	1908 Wheat	1909 Cow-peas[4]	1910 Corn	1911 Cow-peas
101	0..........	15.5	9.3	Removed	1.3	....	16.7	.0	....	33.5	Removed
102	Le..........	13.3	5.0	Turned	10.8	....	17.8	.0	....	35.4	Turned
103	LeL........	14.9	8.3	Turned	18.2	....	30.3	4.5	....	44.7	Turned
104	LeLP.......	12.5	7.4	Turned	25.6	....	37.1	8.3	....	46.6	Turned
105	LeLPK.....	19.9	11.6	Turned	30.0	....	38.1	9.8	....	58.3	Turned
		Oats[1]	Cowpeas[1]	Wheat	Corn	Wheat	Clover	Corn	Wheat	Clover	Corn
201	0..........	19.1	Removed	6.7	37.5	3.8	(.65)	35.2	4.6	(.26)	34.2
202	Le..........	18.8	Turned	7.1	42.9	5.4	(.81)	35.6	6.8	(.04)	30.8
203	LeL........	19.8	Turned	10.0	61.9	17.9	(1.92)	43.9	9.6	(1.45)	38.8
204	LeLP.......	20.0	Turned	14.8	57.2	11.3	(2.56)	42.9	12.8	(1.85)	23.4[5]
205	LeLPK.....	31.7	Turned	17.5	56.5	15.0	(2.23)	50.6	11.3	(2.19)	32.0[5]
		Cowpeas[1]	Wheat	Corn	Cowpeas	Corn	Wheat	Cow-peas[4]	Corn	Wheat	Clover
301	0..........	Removed	.4	30.5	Removed	41.2	4.3	....	23.0	3.1	(.13)[3]
302	Le..........	Turned	.6	35.5	Turned	40.6	6.1	....	24.9	8.7	(.16)
303	LeL........	Turned	.7	49.1	Turned	48.9	13.0	....	31.3	13.5	(.97)
304	LeLP.......	Turned	8.0	49.4	Turned	40.9	13.6	....	32.6	14.4	(.92)
305	LeLPK.....	Turned	11.0	44.7	Turned	40.9	15.6	....	33.5	14.6	(.98)

[1] No legume treatment.
[2] Through error the growth was removed from the plots but not weighed.
[3] Hay very weedy.
[4] The pods were harvested but not weighed by plots.
[5] Very poor stand, due to moles.

these experiments; but in order to produce a thrifty growth of legumes, it was necessary to apply lime. Thus, upon the addition of limestone, the corn yield was increased by one-third, while the wheat yield was practically doubled. In the case of the corn, little or no effect was produced by the addition of either phosphorus or potassium treatment. In the wheat, however, an increase of

TABLE 8.—OLD VIENNA FIELD: SUMMARY OF THE GRAIN CROPS
Average Annual Yields, 1903-1911—Bushels per acre

Soil treatment	Corn *9 crops*	Wheat *8 crops*
0	29.0	3.0
Le	29.8	5.7
LeL	39.7	10.9
LeLP	37.5	13.6
LeLPK	40.7	15.6

about 3 bushels an acre a year appears upon the addition of phosphorus, and a further increase of 2 bushels an acre a year upon including potassium in the treatment.

The yields from the three clover crops are not summarized, but an inspection of the individual results in Table 7 shows some very fair yields of clover on the better treated plots.

Altho these results furnish an indication of the most important needs of this land, it cannot be said that the experiments as conducted represent directly an economical system of farming. Considering the several years in which the land was given over to the growth of a green manure crop when nothing was harvested, even the yields from the best plots would scarcely be sufficient to cover the cost of maintenance. However, it appears possible that by modifying the cropping plan in some manner, as for example, substituting sweet clover for cowpeas and giving large place in the farming system to hay and pasture crops, the yields might be substantially increased and thus a system of farming instituted that would represent a profitable enterprise.

THE NEW VIENNA FIELD

From 1906 to 1924 another experiment field, designated as the new Vienna field, was maintained. This field was located about a mile southeast of Vienna and about a half-mile west of the old Vienna field described above. It embraced 16 acres of the badly eroded hilly land characteristic of the region.

The soil of this field is, in general, of loessial formation. It is strongly acid in reaction. Altho the soil type appears on the county map as Yellow Silt Loam, a detailed examination of the area occupied by the field discloses on a larger-scaled map three separable types, namely, Yellow Silt Loam, Yellow-Gray Silt Loam, and Deep Gray Silt Loam. (See Fig. 6.)

The work on this field from 1906 to 1915 was concerned with an investigation of methods of reclaiming this land primarily thru means of reducing erosion. Before taking over the field, the land, with the exception of about three acres, had been abandoned because so much of the surface soil had been washed away, and gulleying had become so bad that further cultivation was unprofit-

able. Some of the gulleys were four or five feet deep, so that the first step in reclaiming the land was to fill them and thus make the slopes more uniform.

Experiments in Reducing Erosion

The field was divided into five sections. The sections designated as A, B, and C were divided into 4 plots each, and D into 3 plots. On section A, which included the steepest part of the area and contained many gullies, the land was built up into terraces at vertical intervals of five feet. Near the edge of each terrace a small ditch was placed so that the water could be carried to a natural outlet without much washing.

On section B the so-called embankment method was used. By this method erosion is prevented by plowing up ridges sufficiently high so that if the water breaks over, it will run over in a broad sheet rather than in narrow channels. At the steepest part of the slope, hillside ditches were made for carrying away the run-off.

Section C was washed badly but contained only small gullies. Here the attempt was made to prevent washing by incorporating organic matter in the soil and practicing deep contour plowing and contour planting. With two exceptions, about eight loads of manure an acre were turned under each year for the corn crop.

The land on section D was washed to about the same extent as that of section C. As a check on the different methods of reducing erosion, the land on Section D was farmed in the most convenient way, without any special effort being made to prevent washing.

Section E was badly eroded and gullied and no attempt was made to crop it other than to fill in the gullies with brush and to seed the land to grass.

Sections A, B, C, and D were not entirely uniform; some parts were washed more than others and portions of the lower-lying land had been affected by soil material washed down from above. When the field was secured, the higher land had a very low producing capacity. On many spots little or nothing would grow.

Limestone was applied to the entire field at the rate of 2 tons an acre. Corn, cowpeas, wheat, and clover were grown in a four-year rotation on each section excepting D which had but three plots.

Table 9 contains a summarized statement of the results obtained. For a more detailed account of this work the reader is referred to Bulletin 207 of this Station entitled "Washing of Soils and Methods of Prevention."

TABLE 9.—NEW VIENNA FIELD: HANDLING HILLSIDE LAND TO PREVENT EROSION
Average Annual Yields, 1907-1915—Bushels or (tons) per acre

Section	Method	Corn *7 crops*	Wheat *7 crops*	Clover *3 crops*
A	Terrace	31.4	9.0	(.68)
B	Embankments and hillside ditches	32.4	12.7	(.97)
C	Organic matter, deep contour plowing, and contour planting	27.9	11.7	(.80)
D	Check	14.1	4.6	(.21)

FIG. 4.—AN UNIMPROVED HILLSIDE OVER THE FENCE FROM THE FIELD SHOWN IN FIG. 5

These results indicate something of the possibilities in improving hillside land by protecting it from erosion. The average yield of corn from the protected series (A, B, and C) was 30.6 bushels an acre, as against 14.1 bushels for series D; wheat yielded 11.1 bushels in comparison with 4.6 bushels; and clover .82 ton in comparison with .21 ton.

A comparison of Figs. 1 and 2 will serve to indicate the possibility of improving this type of soil.

Later Experiments on the New Vienna Field

Upon discontinuing the above described work on the prevention of washing, an experiment in cropping and fertilizing was begun in 1916 in which the main

FIG. 5.—CORN GROWING ON IMPROVED HILLSIDE OF THE VIENNA EXPERIMENT FIELD. THIS LAND FORMERLY HAD BEEN BADLY ERODED. COMPARE WITH FIG. 4.

FIG. 6.—SOIL MAP OF VIENNA FIELD

feature was a comparison of the relative efficiency of rock phosphate and acid phosphate. For this purpose the land was re-plotted into five series distributed over the field as shown in the accompanying map (Fig. 6). Each series was made up of seven tenth-acre plots which were treated as indicated on the map and in Table 10.

A crop rotation was used which included corn, cowpeas, wheat (seeded to timothy), clover, (with timothy), and timothy.

About 4 tons of limestone an acre was applied to all plots in the fall of 1915, and this was followed by 2 tons an acre each rotation thereafter. The rock phosphate was applied at the rotation rate of one ton an acre in three equal applications, in preparation for corn, for cowpeas, and for wheat. The acid phosphate was applied in the same manner except that only a half-ton an acre was used for each rotation. The crop residues plowed under were for the most part cornstalks. The stalks were rolled down so that they lay at right angles to the slope of the ground. The manure was applied in amounts equivalent to the total weight of all the produce (excepting the cornstalks) removed from the respective plots.

The results of this investigation are recorded in Table 10, which gives the annual acre yields of the respective crops thruout the nine years of the work.

A careful scrutiny of these results reveals something of the difficulties in deriving definite conclusions with respect to the questions that the experiments were designed to answer, but an inspection of the accompanying map of the New Vienna field will explain why some of these difficulties exist. The interpretation of experiment field results, even with land of level topography, almost always presents some difficulties arising from the variation in natural productiveness of the plots. On land of such rough topography as the new Vienna field

TABLE 10.—NEW VIENNA FIELD: ROTATION—CORN, COWPEAS, WHEAT, CLOVER, TIMOTHY
Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1916 Corn	1917 Cowpeas	1918 Wheat	1919 Clover	1920 Timothy	1921 Corn	1922 Cowpeas	1923 Wheat	1924 Clover
101	LRM	10.0	6.2	17.3	(3.46)	(1.30)	24.8	8.8	22.2	(2.52)
102	LRM rP	5.0	6.3	22.0	(2.85)	(1.25)	27.4	9.1	23.2	(2.64)
103	LRM aP	10.9	4.9	25.5	(3.03)	(1.55)	23.5	5.7	27.2	(2.96)
104	LRM	12.1	4.0	22.5	(2.84)	(1.35)	25.5	7.2	25.3	(2.51)
105	LRM rP	10.3	4.0	16.5	(2.65)	(1.00)	24.6	6.0	21.6	(2.54)
106	LRM aP	11.9	4.0	22.5	(2.27)	(1.50)	27.8	3.6	24.0	(2.76)
107	L	11.6	7.8	14.2	(1.87)	(1.00)	22.8	8.8	12.3	(1.29)
		Cowpeas	Wheat	Clover	Timothy	Corn	Cowpeas	Wheat	Clover	Timothy
201	LRM	7.8	15.3	(2.10)	(2.93)	50.0	32.0	27.9	(1.89)	(1.60)
202	LRM rP	9.9	17.8	(2.40)	(3.20)	54.5	33.1	30.1	(2.57)	(1.83)
203	LRM aP	8.8	19.5	(1.97)	(3.53)	52.8	30.0	31.1	(2.51)	(1.71)
204	LRM	9.8	18.3	(2.00)	(3.30)	57.1	29.8	30.3	(1.88)	(1.66)
205	LRM rP	9.6	17.3	(2.30)	(3.01)	54.0	28.5	29.8	(2.59)	(1.73)
206	LRM aP	9.2	12.8	(2.40)	(3.45)	48.9	26.3	26.9	(2.15)	(1.51)
207	L	8.9	6.5	(1.43)	(2.65)	44.2	18.0	14.9	(1.43)	(.87)
		Wheat	Clover	Timothy	Corn	Cowpeas	Wheat	Clover	Timothy	Corn
301	LRM	3.5	(3.28)		3.3	10.3	11.5	(2.65)	(1.37)	31.4
302	LRM rP	3.9	(4.07)		13.1	13.3	14.5	(2.50)	(1.27)	37.0
303	LRM aP	3.5	(4.14)	No yields taken	13.1	11.8	14.8	(2.38)	(1.16)	43.8
304	LRM	10.0	(2.51)		8.7	10.8	12.2	(2.07)	(1.03)	33.1
305	LRM rP	14.3	(2.82)		8.0	11.5	11.8	(2.33)	(1.39)	35.3
306	LRM aP	13.8	(3.46)		7.1	10.7	11.5	(2.32)	(1.24)	28.9
307	L	10.7	(3.58)		6.6	14.7	9.1	(2.09)	(1.04)	26.1
		Clover[1]	Timothy[2]	Corn	Cowpeas	Wheat	Clover	Timothy	Corn	Cowpeas
401	LRM			11.1	8.8			(1.65)	42.9	(1.15)
402	LRM rP			7.3	7.5			(2.30)	35.6	(1.55)
403	LRM aP	No yields taken	No yields taken	7.1	8.0	Wheat winter-killed	No yields taken	(2.51)	31.5	(1.67)
404	LRM			10.7	8.8			(2.25)	42.0	(1.70)
405	LRM rP			15.4	10.0			(2.46)	42.6	(1.87)
406	LRM aP			12.0	7.7			(2.42)	35.6	(2.00)
407	L			10.0	9.2			(2.27)	25.1	(1.27)
		Timothy[1]	Corn	Cowpeas	Wheat	Clover	Timothy	Corn	Soybeans	Wheat
501	LRM		23.2	3.4	12.5	(1.84)	(1.29)	28.7		7.5
502	LRM rP		30.0	4.2	14.2	(2.31)	(1.15)	31.7		9.0
503	LRM aP	No yields taken	48.4	3.3	19.3	(3.00)	(1.65)	48.2	No yields taken	15.2
504	LRM		43.2	4.4	17.0	(2.15)	(1.66)	42.1		15.2
505	LRM rP		39.6	4.2	17.5	(2.30)	(.88)	43.7		16.5
506	LRM aP		46.6	4.8	18.5	(2.75)	(1.29)	48.0		15.0
507	L		38.4	5.6	11.7	(2.25)	(1.31)	56.9		7.7

[1]No soil treatment. [2]No manure.

TABLE 11.—NEW VIENNA FIELD: SUMMARY OF AVERAGE ANNUAL CROP YIELDS SHOWING DUPLICATE PLOTS, 1916-1924—Bushels (or tons) per acre

Crop	LRM		LRM rP		LRM aP		L
Corn (9 crops)	22.8	30.5	26.8	30.4	31.0	29.6	26.9
Cowpeas (7 crops)	11.0	10.7	11.9	10.5	10.4	9.5	10.4
Wheat (8 crops)	14.7	18.8	16.8	18.2	19.5	18.1	10.9
Clover (7 crops)	(2.53)	(2.28)	(2.76)	(2.50)	(2.86)	(2.59)	(1.99)
Timothy (6 crops)	(1.69)	(1.88)	(1.83)	(1.75)	(2.02)	(1.90)	(1.52)

represents, where washing from one plot to another is an inherent feature of the experiment, it is not surprising that the results of crop yields are unusually difficult, or even impossible, of interpretation. The only way of overcoming this kind of obstacle is thru ample repetition and replication whereby the experimental error due to plot variation can, to some extent, be determined. Unfortunately the opportunity for this kind of correction in the new Vienna field results is not very satisfactory on account of the meagre replication of plots.

The detailed results recorded in Table 10 are summarized in Table 11 in such manner as to show the average annual acre yields for the different kinds of crops, averaging the duplicate plots separately.

The discrepancies between duplicate plots so apparent in Table 10 are not wiped out in these summaries, the differences between duplicate plots representing the same treatment exceeding in many cases the differences between plots representing different treatments. Altho these experiments fail to answer definitely the questions they were intended to solve, there are some observations of interest to be made in looking over the data.

In the nine years of the experiments there were three seasons in which the corn crop was practically a failure, the different plots yielding from about 3 to 13 bushels an acre. On the other hand a good crop was produced in 1920, when the yield ranged from 44 to 57 bushels an acre. As to the treatments, it is impossible to conclude from the data which form of phosphate was the more effective on the corn crop, or indeed, whether the manurial treatment including the phosphates had any effect whatever.

There appears to have been only one very good crop of cowpeas (seed). This was in 1921, when the peas occupied the 200 series, and the treated plots produced about 26 to 33 bushels an acre. Owing to some errors known to have occurred in the harvesting, further discussion of the cowpeas is scarcely warranted.

With the exception of the crop of 1916, fair yields of wheat were obtained on the manured plots. The results show a considerable gain for the manurial treatment over limestone alone. No conclusions can be drawn as to effect of phosphate treatment on the wheat crop.

Good crops of clover were grown on these plots. There appears to have been a marked response to manurial treatment over limestone alone and possibly some response to phosphate fertilization, altho the latter increase is not very definite.

Some excellent crops of timothy were harvested and the average yields were good. The results indicate some benefit from the application of the more com-

plete treatments over limestone alone. Rock phosphate produced no significant effect according to average yields, but acid phosphate appears to have given a noticeable increase.

Altho, as stated above, the irregularities of the results preclude the drawing of specific conclusions concerning these various fertilizer treatments, it would appear, upon considering the results on all crops as a whole, to be doubtful whether phosphorus fertilization could be profitably practiced at all in a system of cropping such as was employed in these experiments.

THE ELIZABETHTOWN FIELD

The Elizabethtown experiment field was established by the University in 1917, in the unglaciated hilly section of southern Illinois. This field is located in Hardin county about two miles north of Elizabethtown. The soil is of loessial formation, the predominating type on this field being classified as Yellow Silt Loam. A detailed examination, however, shows the presence of some Yellow-Gray Silt Loam and also a very small patch of Stony Loam. The land is extremely rough in topography, the contour map showing a range in elevation of 42 feet on that part of the field occupied by the present plots. Erosion, therefore, is a serious problem. The field embraces about 32 acres, of which area about one-half is laid off into plots. There are four series of 10 fifth-acre plots each, included in a major rotation. Another series of 10 tenth-acre plots is devoted to another rotation, and in addition to these there are three other plots designated as A, B, and C, upon which a special phosphate test is being carried on.

The major rotation formerly included corn (with rye cover crop), soybeans, wheat, and sweet clover, but this was changed in 1923 to a rotation of corn, wheat, clover-timothy mixture, and wheat with sweet clover seeding on the residue plots. The plot treatments are indicated in the following table of results. The remarks made above in connection with the discussion of the New Vienna field on the difficulty of obtaining satisfactory experimental data on land of such rough topography, apply with equal pertinence to the Elizabethtown field. There are, however, certain effects standing out in such bold relief as to leave no doubt as to their significance. The results for the different crops are summarized in Table 12.

TABLE 12.—ELIZABETHTOWN FIELD: SUMMARY OF CROPS GROWN
Average Annual Yields, 1919-1924—Bushels or (tons) per acre

Soil treatment	Corn *6 crops*	Wheat following legumes *4 crops*	Wheat following corn *2 crops*	Timothy-clover mixture *2 crops*	Soybeans *3 crops*	Sweet clover seed *2 crops*
0	21.4	6.9	5.0	(0.00)	2.7	0.00
M	20.4	6.5	4.4	(0.00)	3.1	0.00
ML	33.5	11.1	10.2	(.90)	4.2	2.59
MLP	38.8	15.4	9.0	(1.45)	5.2	2.42
0	14.5	6.9	2.4	(0.00)	2.3	0.00
R	15.7	6.1	2.9	(0.00)	2.5	0.00
RL	31.8	11.6	4.9	(1.02)	4.3	1.99
RLP	41.3	15.7	5.2	(1.20)	5.0	1.74
RLPK	40.7	16.6	4.9	(1.44)	4.6	1.49
0	22.5	7.3	4.4	(0.00)	3.0	0.00

These results show extremely poor yields on the untreated land, with no improvement from the use of manure alone or residues alone. A sharp increase in yield, however, follows the application of limestone along with either manure or residues. Rock phosphate seems to have produced a beneficial effect on the corn, on the wheat following legumes, and on the timothy-clover mixture, in both the manure and the residues systems. The potassium treatment as applied in these experiments does not show sufficient benefit to cover the cost. The following general observations are of interest. The wheat following legumes has a much more favorable place in the rotation than the wheat following corn, which fact is manifested by the relative yields. Soybeans have not proved a very successful crop on this field. It is of interest to note that the residues system appears to be fully as effective in building up this soil as the manure system, but a rational system of farming might well include livestock, in which the manure as well as all available crop residues would be utilized for soil improvement.

The results from the minor rotation on Series 500 are too few to warrant consideration at this time.

On Plots A, B, and C a comparison of the two carriers of phosphorus, acid phosphate and rock phosphate, is under way. The acid phosphate is applied at the rate of 200 pounds an acre a year and the rock phosphate in double this quantity.

In a rotation of corn, cowpeas, and wheat, four crops of corn, three of cowpeas, and three of wheat can be compared at this time. It is of interest to note the results that thus far have been obtained, bearing in mind that the data are not sufficient to warrant drawing final conclusions as to which carrier of phosphorus will prove to be the more economical to use. Table 13 presents the crop yields from these comparative phosphate tests covering the period since the full soil treatment has been applied.

On the whole, the differences shown in the averages are relatively small, so that it may be said that after four years the data furnish no reliable indication as to which form of phosphate is the more effective in increasing crop yields.

TABLE 13.—ELIZABETHTOWN FIELD: COMPARATIVE TEST OF ACID PHOSPHATE AND ROCK PHOSPHATE

Annual Acre Yields of Crops Grown, 1921-1924—Bushels per acre

Year	Corn		Wheat		Cowpeas	
	Acid phosphate	Rock phosphate	Acid phosphate	Rock phosphate	Acid phosphate	Rock phosphate
1921......	28.8	28.6	....	....	9.2	7.8
1922......	34.4	32.0	3.2	9.8	12.5	4.7
1923......	32.2	46.8	18.6	14.3	10.5	9.2
1924......	54.6	59.2	13.3	8.8	....	....
Average...	37.5	41.7	11.7	11.0	10.7	9.5

THE UNIONVILLE FIELD

The Unionville experiment field is located in the extreme southern part of Illinois, in Massac county, immediately north of Unionville. This field is representative of a soil type classified tentatively as Yellow-Gray Silt Loam, altho it

should be noted that certain features of the soil profile are not altogether characteristic of the large prevailing body of soil mapped in southern Illinois under that type name. However, the results from this field are doubtless applicable to a considerable area of the land in Johnson county, and therefore a brief account of the experiments on the Unionville field are presented here.

This field is undulating in topography. It is thoroly tile-drained. The soil is strongly acid in reaction.

The field includes about 25 acres laid off into two general systems of plots under independent crop rotations. On the first four series, a rotation of corn, cowpeas, wheat, and cotton was started, but this was changed in 1922 to corn, rye, cowpeas, and wheat with sweet clover seeding on the residue plots. In 1924 the rotation program was again altered by replacing the rye with cotton. Table 14 indicates the various soil treatments included in the experiments and also summarizes the results obtained with each of the principal crops grown covering the time since full soil treatment has been in effect.

TABLE 14.—UNIONVILLE FIELD

Average Annual Yields of the Principal Crops, 1912-1924

Serial Plot No.	Soil treatment applied	Corn *10 crops*	Wheat *10 crops*	Cotton *10 crops*	Cowpeas[1]
		bu.	*bu.*	*lbs.*	*bu. or (tons)*
1	0	18.2	6.2	190	(.67)
2	M	24.0	8.5	315	(.80)
3	ML	31.4	14.6	501	(1.10)
4	MLP	32.0	18.3	522	(1.34)
5	0	16.8	6.6	154	3.5
6	R	19.8	7.9	138	3.9
7	RL	34.7	16.2	254	4.5
8	RLP	37.5	20.2	263	4.8
9	RLPK	42.6	21.8	459	6.0
10	0	17.1	7.0	162	(.66)

[1] Ten crops of hay on manure plots, 8 crops of seed on residue plots.

In looking over these results one may note the very poor yields on the untreated plots. Manure alone produces only a moderate improvement, and residues alone give on the whole very little, if any, benefit. Limestone, however, proves to be the critical factor in the improvement of this soil as evidenced by the sharp increases in crop yield where this material has been applied. The phosphorus plots show some increase for all crops, but the principal effect is on the wheat. Potassium, as applied in these experiments, likewise shows some increase in all crops, but more especially in the corn and in the cotton.

On the whole, the crop yields appear to be maintained just as well in the residues system as in the manure system, thus demonstrating the possibility of building up this soil without animal manure. For farm practice, however, the recommendation would be to make use of all available manure along with crop residues for supplying organic matter and nitrogen.

The work going on at present on the smaller series of plots of the Unionville field has as yet not been continued long enough to warrant summarizing at this time.

Soil Reports Published

1 Clay, 1911
2 Moultrie, 1911
3 Hardin, 1912
4 Sangamon, 1912
5 LaSalle, 1913
6 Knox, 1913
7 McDonough, 1913
8 Bond, 1913
9 Lake, 1915
10 McLean, 1915
11 Pike, 1915
12 Winnebago, 1916
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17 Kane, 1917
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21 McHenry, 1921
22 Iroquois, 1922
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24 Adams, 1922
25 Livingston, 1923
26 Grundy, 1924
27 Hancock, 1924
28 Mason, 1924
29 Mercer, 1925
30 Johnson, 1925